POWER PLANT ENGINEERING

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Caribou Power Plant Completed

SECOND PLANT IN FEATHER RIVER DEVELOPMENT OF THE GREAT WESTERN POWER CO. IN OPERATION. BY CHARLES W. GEIGER

BECAUSE THE CARIBOU power project, as one section in the power development of the Great Western Power Co. of California, was undertaken on the very heels of the cessation of World War hostilities, Central California is saved, this summer, the losses suffered from the power shortages in 1918, 1919, and 1920. Of even greater importance, this large area, with its rapidly increasing population, may go forward confidently in the development of its resources, knowing that, as the need arises, power and more power may and will flow to it from the perpetual reservoirs of the mountains.

The power development area of the Great Western Power Co. of which the Caribou development is a unit, begins in Lake Almanor, the source of the North Fork of the Feather River, and ends at Oroville, 75 mi. distant, a drop in altitude of more than 4000 ft. The whole project, expressed briefly, consists in using the waters of the river over and over again during this drop, for the generation of hydroelectric power, and finally dis-

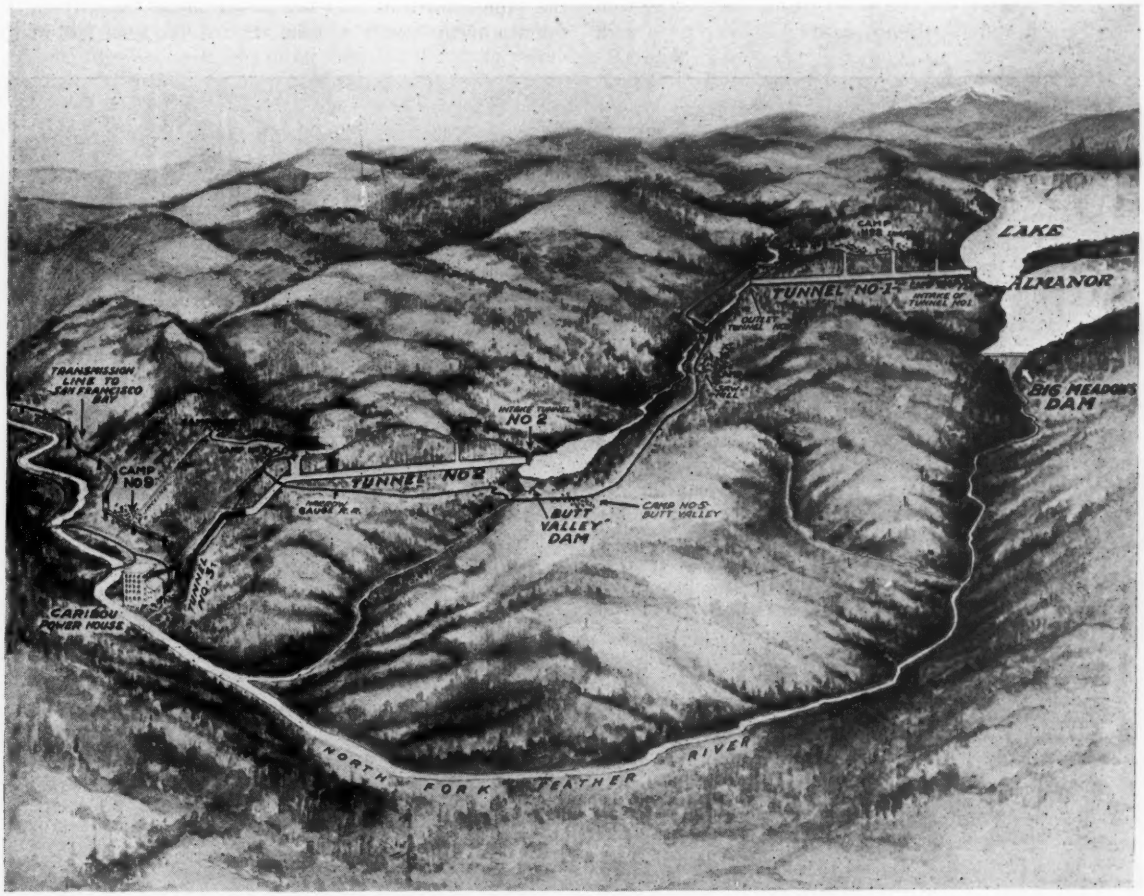


FIG. 1. ARTIST'S PERSPECTIVE OF CARIBOU DEVELOPMENT

tributing them for irrigation purposes when they have reached the Sacramento Valley levels.

Through the power thus developed the Great Western Power Co. of California now furnishes more than 300,000 hp. for California agriculture, business and industry, including mines, factories, gold dredgers, railroads, commercial and domestic lighting and cooking and heating.

Practically all of this service has been connected within 10 yr., and probably within the next 15 yr. the ultimate Feather River power development of this company will reach 640,000 hp. The additional cost of this development is estimated at $200,000,000.

To insure an adequate supply of water at all seasons, a dam was built in 1913, at the lower end of Big Meadows, impounding 300,000 acre feet of water, and creating the lake known as Lake Almanor, the largest artificial power reservoir in the world. This lake is fed not only by drainage, but by great springs, with a flow of from 600 to 700 cu. ft. per sec. The output of these springs alone would be sufficient to operate the present installed capacity of the Caribou plant. By increasing the height of the dam, the lake's storage capacity can be augmented by 1,250,000 acre feet, and from this reservoir, to which is added the drainage into the river's course below the dam, comes all the water for use in the seven power sites so far selected. Two of these sites—Big Bend and Caribou—are now partially developed. Development of the others and the completion of the Caribou and Big Bend plants will keep pace with the increasing need for hydroelectric power, until a total capacity of 640,000 hp. is reached.

To feed the Caribou with water, was in itself an engineering undertaking of magnitude. Tunnel No. 1, 11,200 ft. long and with a capacity of 800 cu. ft. of water per second, was built to carry the waters of Lake Almanor, regulated by two 7-ft. electrically controlled gates, into Butt Valley, down which they course to tunnel No. 2, 9200 ft. long and with a capacity of 1400 cu. ft. of water per second, which leads them to the pressure tunnel. At the bottom of the pressure tunnel a horizontal tunnel 550 ft. long carries, at the present time, two 60-in. steel penstocks which are attached to the pressure tunnel and made watertight by means of a large concrete plug. There is space in the horizontal tunnel for a third pipe of similar dimensions. The pipe lines emerge from the horizontal tunnel and are anchored on the surface of the hillside a distance of 547 ft. to a point where they drop vertically into another tunnel known as the "uprise" which is about 550 ft. deep. About half way down the "uprise" the 60-in. pipes, by means of large Y connections, branch into four 42-in. pipes. A tunnel running horizontally from the bottom of the "uprise" carries the pipe lines about 500 ft. to the surface of the mountain side immediately back of the power house. From this point the pipe lines are laid on concrete anchors to four hydraulically operated gate valves which are installed against the rear wall of the power house. From these valves the pipe lines lead into the power house directly to the nozzles of the water wheels. Space has been left in the

FIG. 2. INTERIOR OF CARIBOU POWER PLANT SHOWING MAIN GENERATORS

"uprise" and horizontal tunnels for two more 42-in. pipe lines.

The present installation, two 30,000-hp. units, consists of two overhung impulse wheels, each with 21 buckets, each bucket weighing 1000 lb. There is room for four similar units, when the building is completed.

The plant is a monolithic reinforced concrete structure 104 ft. 3 in. in width and 178 ft. in length at present but eventually will be 308 ft. in length. The building is 120 ft. in height from the basement to the highest point. A 175-t. crane runs the entire length of the power plant with a span of 47 ft., which is amply capable of handling the largest equipment. The high tension bus rooms each 26 ft. in height and 30 ft. wide extend the full length of the power plant.

Power Transmission System

Caribou hydroelectric power station is located on the Feather River in Plumas County, California, approximately 40 mi. by transmission from the present Big Bend power house of the Great Western Power Co. and approximately 220 mi. from San Francisco. The station is designed for an ultimate capacity of 133,340 kv.a. generating three-phase alternating current at 11,000 v., 60 cycles. The present capacity of the station is 44,446 kv.a.

Generator voltage is raised to approximately 165,000 v. by means of step-up transformers and the power carried by one transmission line to a substation located at Valona about 30 mi. from San Francisco. In the ultimate arrangement there will be three outgoing transmission lines and one incoming line for a future development. The Valona substation is the immediate terminus of the 165,000 v. transmission system. Various feeders leave this substation at 100,000 v., 22,000 v. and 11,000 v. Two 15,000-kv.a. synchronous condensers are installed at present in this station. In the ultimate arrangement there will be six synchronous condensers installed here.

The transmission line is about 190 mi. long, consisting of one circuit of three conductors. The normal voltage of the system is 165,000 v. between wires at the generating station and 150,000 v. between wires at the receiver end. All main step-up transformers of the power station are connected delta on the low-tension side and star with the neutral grounded on the high-tension side. The power factor of the load without transmission lines or synchronous condensers is about 80 per cent. The 165,000-v. lines connect to the existing system at two points and in the manner described below:

A. At Big Bend power station 100,000 v. three-phase and 44,000 v. three-phase.

B. At Valona substation 100,000 v. three-phase.

A. At a point where the 165,000-v. lines pass the Big Bend power house they are connected to the 100,000-v. delta system by means of compensators star connected and grounded and provided with a tertiary winding, this tertiary winding being used in each bank of three compensators to form a closed delta. (This grounds the 100,000-v. system). There is a 44,000 v., three-phase line leaving the Big Bend power house through a 3600-kv.a. transformer bank connected delta on the 11,000-v. or generator bus side and star with the neutral grounded on the 44,000-v. side. (This grounds the 44,000-v. system). This line connects to a 44,000-v. line, leaving the Caribou power house and having a 6000 kv.a. bank of transformers connected delta on the low-tension and delta on the high-tension side.

The above 44,000-v. system has no connection with the system leaving Valona.

B. At Valona substation the 165,000-v. system is again connected to the 100,000-v. system by means of star connected and grounded compensators provided with a tertiary winding, the tertiary winding being used in each bank of three compensators to form a closed delta. The synchronous condensers at this substation are connected to the delta connected tertiary windings.

Hydraulic Equipment

Two 30,000-hp. 171-r.p.m. two bearing impulse Allis-Chalmers water wheel units operating under 1008 ft. net effective head, each consisting of two 15,000-hp. water wheels, which are overhung on the extended ends of the main shaft, are at present installed. Constant speed is maintained by four oil pressure governors, each with regulating cylinder and connections to the needle and pressure regulator, and provided with an independent hydraulic hand operating device. Four pressure regulators are direct connected to and actuated by the

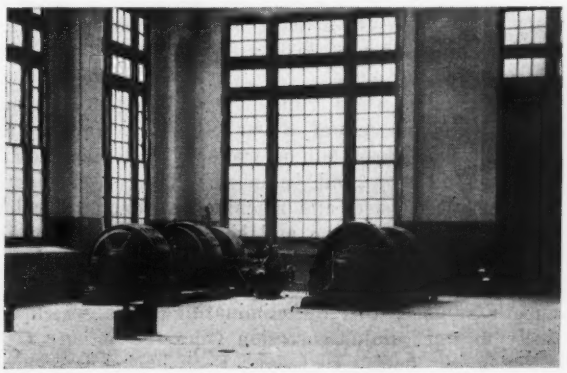


FIG. 3. EXCITER UNITS

governor and nozzle needle. A central oil pressure system is arranged with duplicate oil pumps, pressure and receiving tanks, with capacity for supplying oil to three main units of 30,000-hp. each and one exciter unit of 800-hp. An 800-hp., 600 r.p.m., impulse water wheel overhanging on the extended end of the exciter generator shaft and for operation under 1000 ft. net effective head, drives the exciter unit. This water wheel is also provided with an oil pressure governor for controlling the speed of the exciter.

Each hydroelectric unit consists of one generator and two water wheels. The main shaft is carried in two self-alining bearings, and has a generator rotor pressed on and keyed to it near the center of the shaft. Each water wheel runner and nozzles is an independent prime mover in itself, as pertains to governor flyballs and regulating cylinder and pressure regulator. The unit is placed with the nozzles below the floor line, so that spray and full jet, in the event of runaway, will discharge straight forward to the tail race.

Each nozzle is stationary and the diameter of the water jet is regulated by a governor operated needle. The regulating cylinder is attached to the rear of the

nozzle on the center line of the needle, and the piston in the cylinder is secured to the backward prolongation of the needle stem, which will form the most direct and positive regulating connection possible to secure. A hand operated hydraulic device is arranged for each nozzle to operate the needle independently of the oil pressure system.

Penstocks are protected by two pressure regulator relief valves per unit against pressure rises caused by the sudden closing of the needles by the governors, one pressure regulator being connected to each nozzle pipe. Each pressure regulator is actuated by the adjacent needle stem and is opened synchronously when the needle is closed quickly, thereby preventing excessive pressure rises. The pressure regulator will then close slowly in order to prevent pressure surges and to economize the water supply. Water bypassed through the pressure regulator will be discharged through an elbow horizontally into the wheel pits.

Each water wheel is covered by a housing which is split along the horizontal center line of the wheel. Leakage of water along the main shaft where it enters the housing will be prevented by the centrifugal action of the wheel against a stationary sleeve which surrounds the shaft and the side of the wheel hub. All of the flanged connections in the water piping are made with male and female fits with grooves arranged for round packing which insures leak proof joints with positive alinement of the pipes.

Each water wheel runner consists of a cast and forged wheel center and of buckets, individually bolted thereto. The wheel hub is made of cast steel and is machined all over and balanced. The wheel disk is made of forged steel and machined all over. The hub is bored for pressing on and keying to the end of the generator main shaft. The buckets are made of cast steel with bowls cast smooth and then ground to a smooth surface, thereby eliminating flaws which are likely to start undue corrosion from the action of the water on the bucket surfaces. Each bucket is securely bolted to the wheel center by three fitted open hearth steel bolts and nuts which are locked securely with pins.

Buckets are made interchangeable by machining down to a point or reaming the bolt holes. Extra buckets have been made with the holes slightly undersize so that they may be reamed out in the station exactly to match the holes in the wheel center.

The housing is split at the center line of the shaft into a lower and an upper part. The lower housing is made of cast iron and provided with a flange forming a gutter in the floor for catching condensate water. A drain is provided from the gutter to the wheel pit. A portion of the gutter flange extends downward to secure the housing to the concrete foundation. A handhole with cast-iron cover is provided on the side of the housing near the nozzle for inspection of the nozzle head, needle and buckets. The upper housing is riveted up of steel plate and angle irons calked water tight and stiffened with "T" flange to prevent breathing. It is riveted to a cast-iron flange which is bolted to the machined top face of the lower housing.

On the upper and lower housing parts is a spray deflecting sleeve for preventing water from leaking out along the shaft. This spray deflector surrounds the main shaft where it extends into the wheel housing and closely matches the contour of the hub of the wheel center.

Main bearings are of the ring oiling generator type with shells of the ball and socket seat design. The shells are cored out for water cooling chambers which are provided with pipe connections extending to the outside of the bearings. The shells are built of a rugged construction so that there will be practically no deflection at the ends, consequently the surface pressure will remain uniform.

The shells are designed to permit of removal by taking off the bearing cap and jacking up and blocking the shaft. The bearing pedestal forms a liberal oil basin from which the oil rings draw up the oil. Leakage of oil along the main shaft is prevented by centrifugal oil

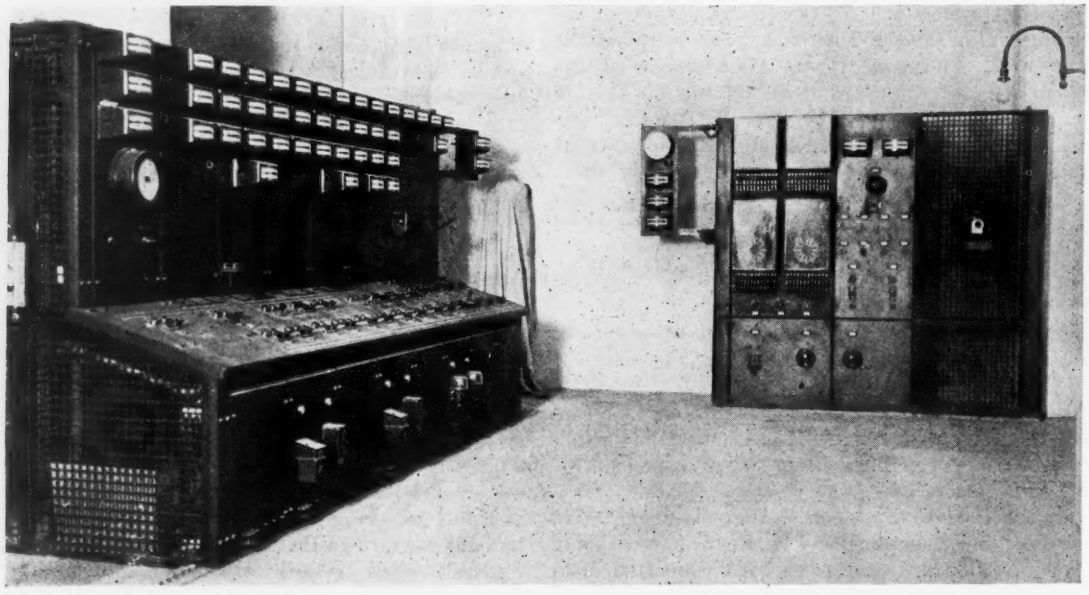


FIG. 4. MAIN SWITCHBOARD CONTROLLING ALL EQUIPMENT IN POWER PLANT

throwers cut into the shaft at the limits of the bearing surface.

Each of the main shafts is forged out of a single open hearth steel ingot. Each shaft is hollow bored, machined smooth and polished in the bearings and has thrust and oil throwing rings turned out of the solid forging at the limits of each bearing surface. The shafts are 25 by 72 in. in the bearings, 30 in. in diameter at the generator rotor and approximately 31 ft. 6 in. in length.

The nozzle pipe is "S" curved and cast with a side pocket through which the needle passes to the outside of the pipe. The pipe is made of cast steel and is flanged at each opening to connect to the nozzle head,

83½ per cent at 0.6 of full load.
82½ per cent at 0.5 of full load.

Each oil pressure governor for the regulation of the water wheels consists of, first, a governor stand with flyballs, regulating valve, relay hand wheel, synchronizing attachment load limiting device and instrument mounted on the generator room floor, and, second, of a regulating cylinder and independent hand operating device secured to the rear end of the nozzle pipe. Normal working oil pressure is 150 to 200 lb. per sq. in. with a maximum of 250 lb. The flyballs are of a design which insures highest sensitiveness combined with ample power and dependable reliability of opera-

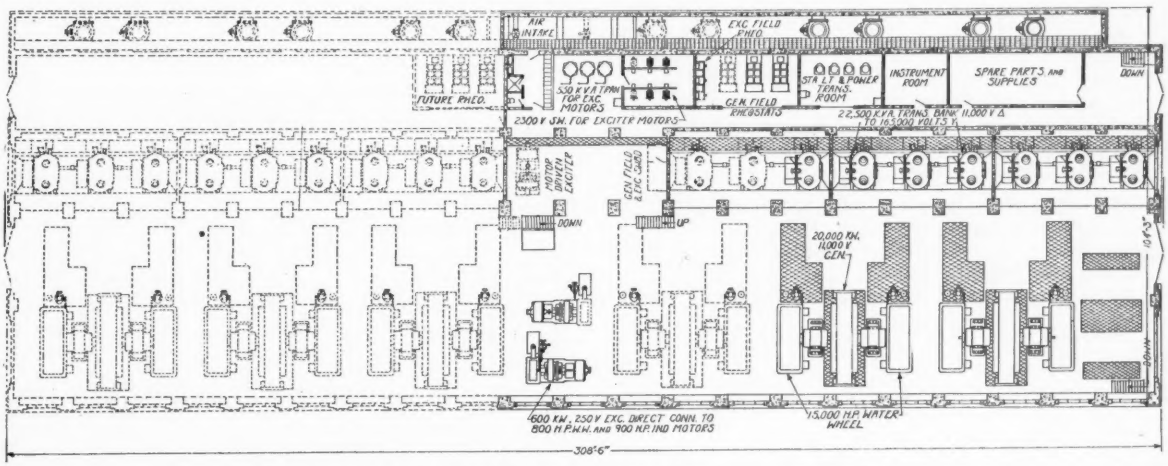

AIR INTAKE
EXC. FIELD RHEO.
FUTURE RHEO.
550 K.V.A. TYPH FOR EXC. MOTORS
GEN. FIELD RHEOSTATS
STA. LT. & POWER TRANS. ROOM
INSTRUMENT ROOM
SPARE PARTS AND SUPPLIES
DOWN
2300 V. SW. FOR EXCITER MOTORS
22,500 K.V.A. TYPHS. BANK 11,000 V. Δ TO 16,500 VOLTS Y
GEN. FIELD EXC. CABLE
DOWN
UP
20,000 KW. 11,000 V. GEN.
600 KW., 250 V. EXC. DIRECT CONN. TO 800 H.P. W.W. AND 900 H.P. IND. MOTORS
15,000 H.P. WATER WHEEL
308'-6"

FIG. 5. PLAN OF CARIBOU POWER PLANT SHOWING PRESENT AND FUTURE EQUIPMENT

the regulating cylinder, the relief valve and the penstock companion flange. The side pocket of the pipe is bored for a bronze bushed needle guide in which the needle slides. The nozzle head is made of cast steel and bolts to the nozzle pipe with a male and female fit. A renewable bronze throat ring is clamped in the head by a cast-steel ring secured to it.

The needle consists of a renewable forged steel tip screwed onto a forged steel needle stem. The stem slides in the bronze bushed guide and extends to the exterior of the pipe, through an adjustable hemp packing box particularly adapted for the high operating pressure, and then into the regulating cylinder, where the piston is firmly secured to the stem. The nozzle is joined to the lower housing of the wheel by a cast-iron retaining ring which effectively seals the housing and prevents spray from being dashed into the nozzle pit.

Power and Efficiency Guarantees

Each pair of water wheels is guaranteed to deliver not less than 30,000 b.hp. to the generator shaft when operating at a speed of 171 r.p.m. under an effective head of 1008 ft. The average efficiency of each pair of water wheels when operating at a speed of 171 r.p.m. under 1008 ft. effective head with the load divided equally will not be less than

81 per cent at full load.
82½ per cent at 0.9 of full load.
83½ per cent at 0.8 of full load.
84 per cent at 0.7 of full load.

tion. They are completely encased, are self-lubricating and belt driven from the main shaft.

The regulating valve is double acting, balanced and of ample size to enable quick and liberal distribution of oil to the regulating cylinder. The fact that practically no energy is required for its operation by the floating lever and flyballs insures highest sensitiveness resulting in correct speed regulation. The regulating valve consists of an advance valve and a main distributing valve and this causes the return of the distributing valve into midposition without necessitating the use of any displacement or so-called anti-racing devices. The motion of the valve is therefore correct, positive and not dependent on the correct functioning of an additional device. The relay compensating device is of the double floating lever type.

Ratio of the speed variation between no load and full load can be adjusted from 5 per cent to as small a variation as is desirable for parallel commercial speed regulation. The regulating cylinder is bolted onto the rear end of the nozzle pipe on the center line of the needle stem body. It contains the piston which is provided with metal rings, eliminating the use of any packing and reducing oil leakage to a minimum. The piston is screwed to needle stem, which results in a construction which completely eliminates pin connections and ultimate lost motion due to the wear on bushings.

By means of the load limiting device the maximum load taken by the governor can be adjusted to any desired degree. It makes it impossible for the governor

to open the needle of the nozzle beyond a predetermined amount, even in case of a dead short circuit. This device is very useful in cases where the available flow is limited at times, or in cases of exceptionally low power factor when a full water load would overload the generator.

By means of this device the governor can also be "blocked" for a constant load, but will be ready at any time to close the needle as soon as the power demand falls below the load setting. This device is so designed that no strains are imposed upon the flyballs or upon the floating lever, so that no heating of bearings or collar will occur.

Each governor is provided with a small direct current motor which is connected to the floating lever and by means of which the speed of the unit can be controlled from the switchboard when cutting the unit in on the line.

This device has been designed for highest efficiency and reliability, is mounted on top of the regulating cylinder and can at any time and in any position of regulating piston be connected to or disconnected from the regulating shaft. It is self-locking and of ample ratio so that the needle can be readily operated by the manual force of one man. All parts of the governors are made interchangeable and can at any time and on short notice be replaced upon demand.

Each turbine is provided with a governor actuated pressure regulating relief and bypass valve which is actuated with the nozzle needles to insure positive and synchronous motion and is operated by water under penstock pressure. It operates as a water saving device, opening simultaneously when the nozzle needles are suddenly closed and slowly and automatically closing after the gates are held stationary. The closing time of the water saving device can be adjusted at any time during operation to suit the pipe line and operating conditions.

The main bypass is contained in a 90-deg. cast-steel elbow secured to the side of the nozzle pipe and is arranged for downward discharge. The main cylinder is cast to the upper side of the elbow and contains the operating piston. The valve orifice is in the lower part of the elbow and has a renewable bronze seat. The valve disc and the main operating elements in the main cylinder are joined by a heavy vertical steel rod.

The central oil system for the governors includes two duplicate oil pumps, two motors and one water wheel, double receiving tanks, pressure tanks, oil headers, but oil distributing tubing for only two main units and one exciter unit.

For the central oil system there are two Allis-Chalmers induction motors, each backgeared to a rotary gear type oil pump, each with a capacity of approximately 85 gal. of oil per minute and designed to operate under a pressure of 200 lb. to the sq. in. Each pump unit is of sufficient size to supply oil to the governors of three main units and one exciter unit. The pumps are arranged in line and with an impulse water wheel in the center and the motors on the extreme ends.

The pump unit is of the single stage double rotary type and consists of a cast-iron base upon which the pump housing is mounted. Attached to each end of the housing is a cast-iron casing containing one pair of cut gears of special design so that the lost space is a minimum and consequently air can be taken into the

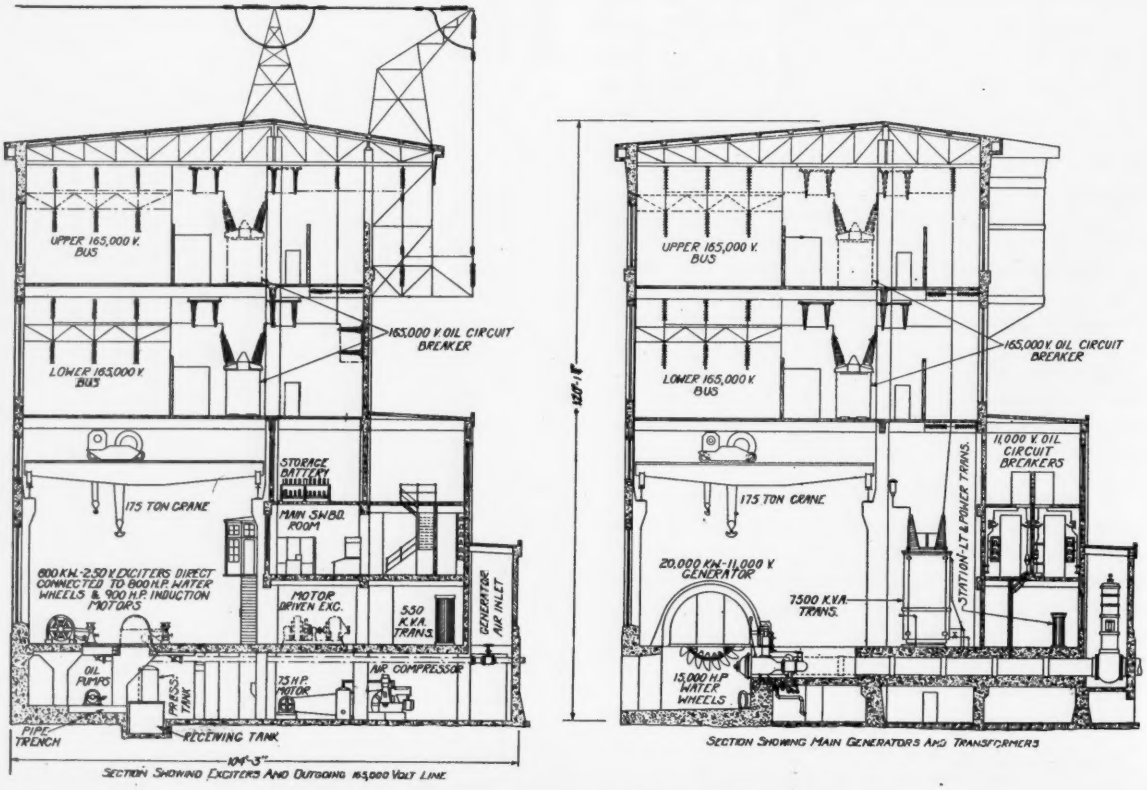


FIG. 6. SECTIONS THROUGH THE POWER PLANT

two pump chambers and compressed for use in the pressure tanks. One gear each of the two pairs is keyed to a common shaft which carries the spur gear driven from a shaft directly coupled to the induction motor. The other two gears revolve idly.

All bearings are entirely self-lubricated. No packing boxes are used with these pumps and the absence of any suction or pressure valves renders this type of pump reliable and simple for both operation and maintenance. The cast-iron base also carries the induction motor, thus making the whole pumping unit self-contained and of substantial construction.

There is one large steel receiving tank which has two independent compartments so that either may be cleaned while the other is in operation. The tank is of sufficient capacity to hold the return oil from the whole system (three main and one exciter units). A

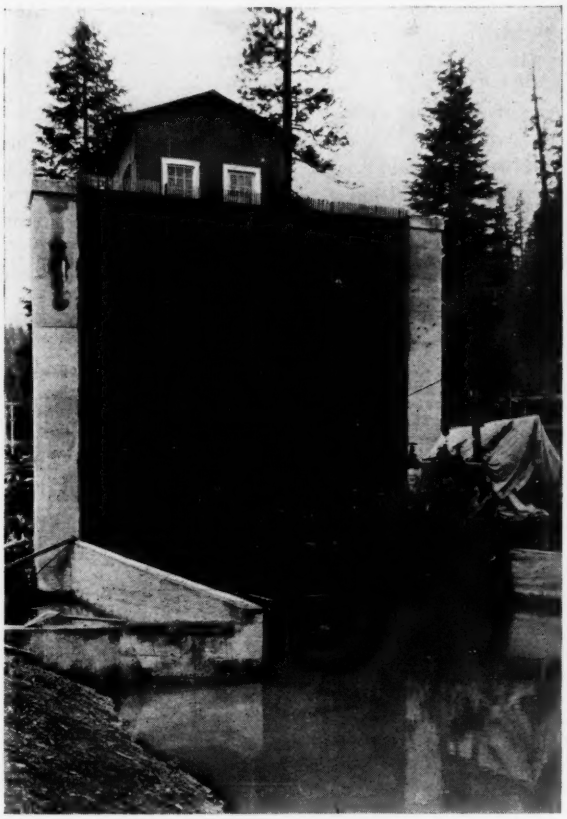


FIG. 7. INTAKE TO TUNNEL NO. 2

screen is provided over each tank, so that any coarse foreign material entering from the return pipes will be removed.

An air pipe connects the pressure tanks to obtain pressure equalization. The oil pressure piping is made of steel tubing with all bends made with a large radius so as to offer as little resistance as possible to the passage of oil. All oil pressure piping and fittings subjected to pressure will withstand a test pressure of 300 lb. per sq. in.

An unloading valve is located in the line between each pump and the pressure tanks. This valve holds the oil pressure in the system between certain desired limits, and allows the pumps to be relieved of the pressure until they are called upon to restore the pressure in the system.

An oil relief valve is provided between the pressure tanks and the receiver tank which, in case of failure of the unloading valves, returns that amount of oil to the receiver tank which is furnished by the excess over that which the various governors may require.

FIG. 8. EXTERIOR VIEW OF POWER PLANT LOOKING UP-STREAM

The two 22,223-kv.a. generators are three-phase, 60-cycle, 11,000-v., direct connected to the overhung water wheels. For ventilation the machines are provided with sheet steel enclosing shields so arranged that air can be drawn in from a duct below and discharged through holes in the frame into the room. Each generator requires approximately 60,000 cu. ft. of air per minute and ducts of about 60 sq. ft. cross section have been provided. Temperature detectors have been installed at six places in the stator winding and brought out to a terminal block on the machine frame.

A rheostat installed with the generator for use in the field circuits to control the voltage is so designed that when the machine is operating as a generator, its range will be sufficient to reduce the voltage of the machine when cold to 85 per cent full load volts at no load, the exciter voltage being 250 v. The rheostat is mounted at a point remote from the switchboard and is operated by a 110-v. direct current motor mounted on the rheostat dial.

Stator laminations are securely mounted upon the stator frame and are of material of permanently high permeability, so treated and assembled as to reduce eddy currents, suitably spaced to provide for proper ventilation and slotted to receive the stator conductors.

Following is a list of electrical equipment installed at the present time:

Two water wheel and induction motor driven 600-kw. 250-v. exciter generators. Two 2300-v. three-phase, 60-cycle, 600-kw. (d.c.) induction motors. One 3.5-kw.

storage battery charging set. Seven O. I. W. C., 165,000-v. to 11,000-v. 7500-kv.a. transformers. Three O. I. S. C., 11,000-v. to 220/110-v., 125-kv.a. transformers. One O. I. S. C., 11,000-v. to 220/110-v., 125-kv.a. transformer (spare). Three O. I. S. C., 11,000-v. to 2300-v. 350-kv.a. transformers. One oil treating outfit. One electric storage battery.

The 7500-kv.a. transformers are designed with full kv.a. capacity taps in the high-tension winding for 150,000/120,000/110,000 v. The tank is circular at the ends with straight sides all of steel plate with welded seams. The sides are reinforced with "Z" bars to prevent any possible distortion when filled with oil. The whole structure is mounted on a support constructed of channel pieces and cast-steel blocks. Flanged wheels are provided for moving the transformer. Heavy studs are attached to the supports and pass up the sides of the tank through rim and cover. Eye bolts are attached to the top of the studs for lifting the complete transformer filled with oil.

The oil conservator outfit which takes care of expansion and contraction consists of a tank cylindrical in form, of steel plate construction, provided with a chloride breather, relief valve and oil gage.

High-voltage windings of the transformers are subdivided into a number of coils, all being of the disk type with one turn per layer of rectangular conductor wound flat. All turns are insulated from each other by pretreated cable paper and cotton covering. The coils at the line ends consist of a few turns with an increased number of paper coverings for the conductor, and the coils heavily re-enforced with varnish cambric tapings.

After winding, the coils were given the high temperature vacuum treatment to remove all traces of moisture. This was followed by an impregnation process under pressure which greatly increases the dielectric strength between turns and renders the coils moisture proof. The individual coils are mechanically separated and insulated from each other by oil ducts and a continuous pressboard diaphragm. The oil ducts are maintained by spacing strips installed radially from the core.

At each end of the stack of high-voltage coils a metal plate is installed against the end coils and electrically connected to them at the beginning and end of the windings, although the body of the plate is insulated from the coils by a continuous diaphragm and spacing strips for oil duct similar to the insulation between the coils themselves. The function of this buffer plate is twofold:

1. To form a rigid mechanical support for the coils.
2. To afford a possible discharge path to ground in case of excessive voltage disturbances, without injury to the winding. The presence of this plate also reduces liability to discharge at a given over voltage, on account of distribution of such voltage over a large area.

The 11,000-v. winding is cylindrical in form, having one electrical turn per layer of rectangular conductor wound flat. All conductors are separated from each

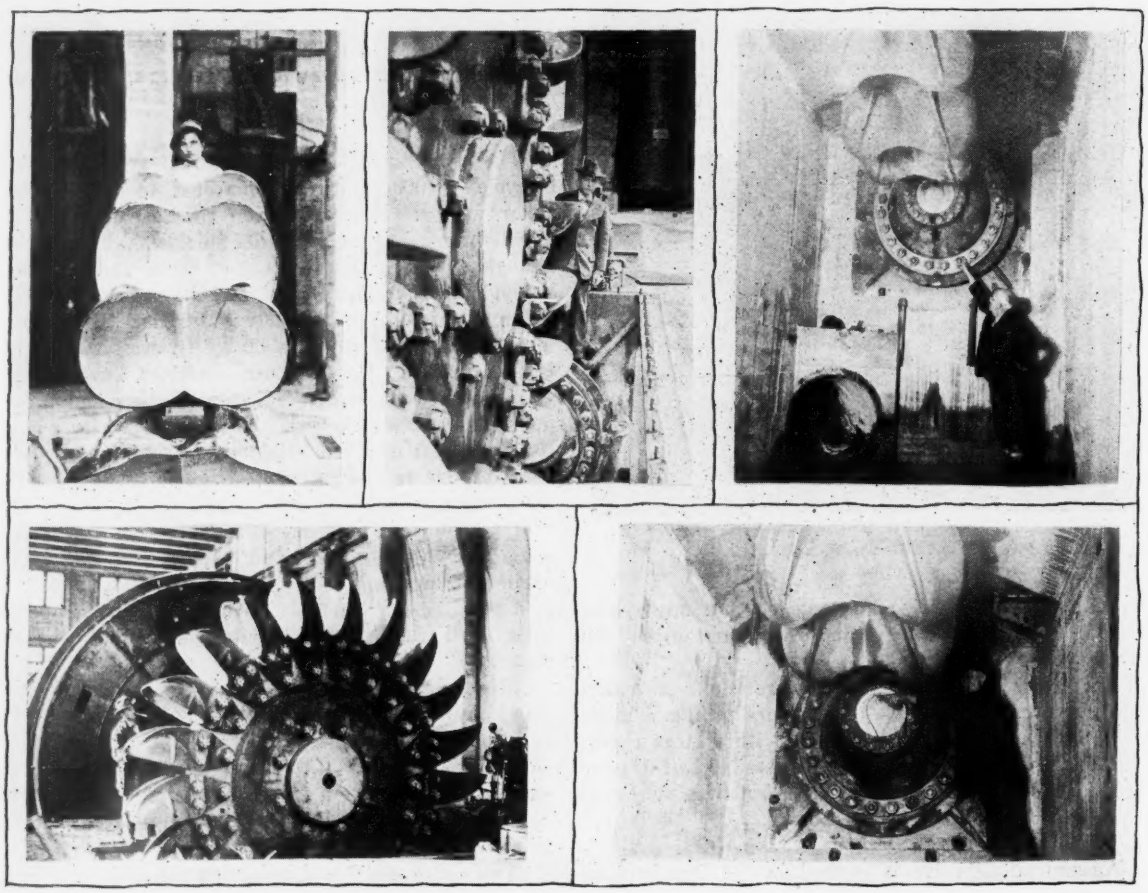


FIG. 9. CLOSE-UP VIEWS OF WATER TURBINE DURING CONSTRUCTION

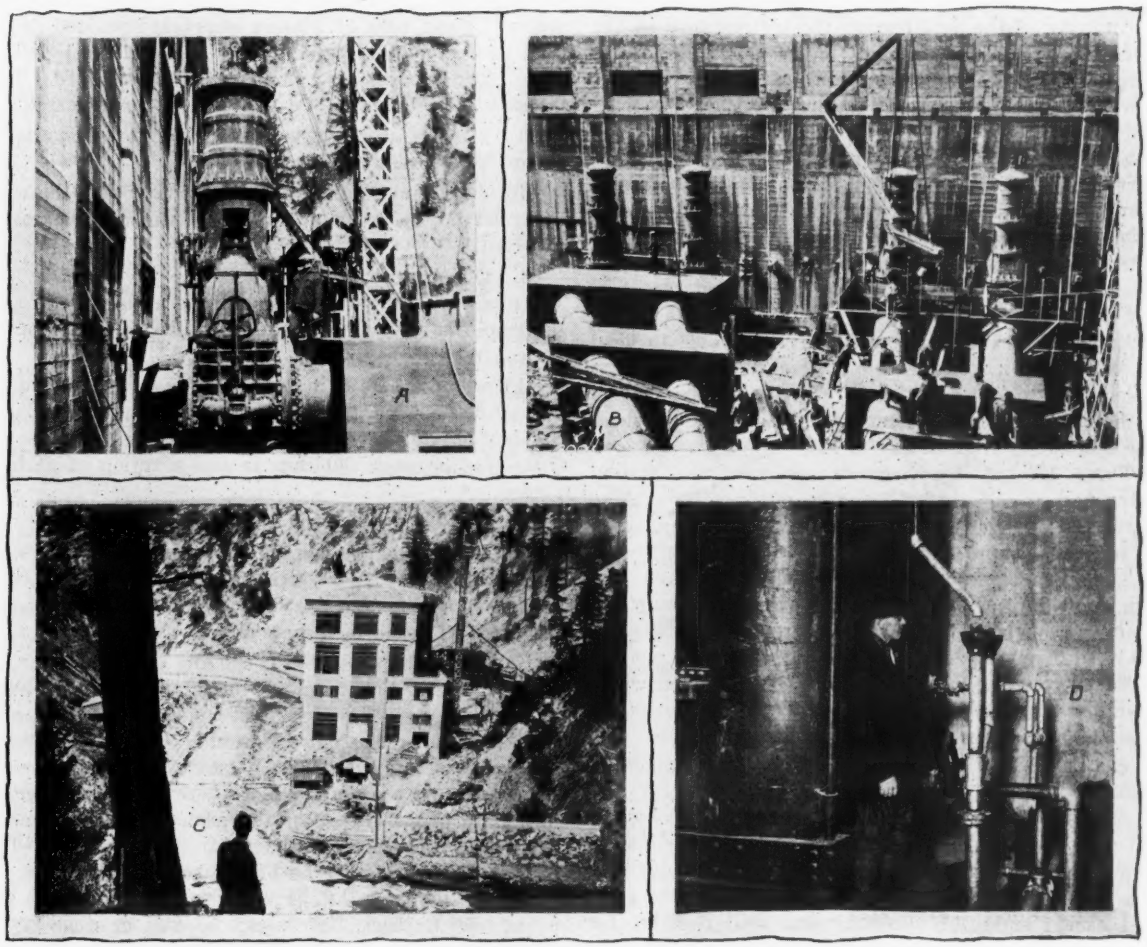


FIG. 10. A. PENSTOCK VALVE AT POWER HOUSE. B. PENSTOCK ENTERING POWER HOUSE. C. POWER HOUSE IN BEND OF RIVER LOOKING DOWN-STREAM. D. COOLING WATER CONNECTIONS TO TRANSFORMER

other by pre-treated cable paper and cotton covering. The coils are separated from the core, first, by kiln-dried maple rods, next by a treated fibrous cylinder of high mechanical and dielectric strength and finally, by treated pressboard spacing strips, thus allowing two oil ducts between iron and windings, and a solid insulating cylinder. The coils are supported at top and bottom between adjustable supports anchored to the core plates.

The electric storage battery equipment consists of one 60-cell storage battery of the chloride accumulator type made by the Electric Storage Battery Co.

Charging and discharging characteristics are as follows:

Normal charge rate	25 amp.
Discharge rate 8 hr	25 amp.
Discharge rate 5 hr	35 amp.
Discharge rate 3 hr	50 amp.
Discharge rate 1 hr	100 amp.
Discharge rate 20 min	200 amp.

Protection against lightning is afforded by a three-phase, four-tank, 60-cycle, 11,000-v. aluminum cell, outdoor type lightning arrester. The feeder reactors consist of three type C1-S single-phase, 60-cycle, 40-kv.a., 315-amp., 127-v., to give 2 per cent drop in a 6000-kv.a. 11-000-v. circuit. These reactors are of the cast-in-concrete type made up of copper cable concentrically wound and supported in concrete webbing, the entire structure being mounted on a concrete slab.

The battery charging set has a 3.5-kw. (50 per cent over load for 2 hr.), 140-v. generator and a 5½-hp. 220-v., three-phase, 60-cycle induction motor. There is a two-unit set connection between the motor and generator made through a solid coupling on the end of the shaft.

Exciter generators are two in number, each 600-kw., direct current, compound wound and operate at 600 r.p.m. The generator has been especially designed for voltage regulator operation, working at all times on the straight part of the saturation curve. There is a motor operated rheostat of capacity sufficient for the control of the voltage from the full value required down to zero. The induction motors are 900-hp. of the squirrel cage type and are direct connected to the combination water wheel and induction motor exciter. The motor operates at 600 r.p.m. and is designed for self-starting the set from reduced voltage tap on the 2300-v. side of the 1650-kv.a. transformer bank. The brushes are staggered so that there will be no serious grooving or uneven wear on the commutator.

The temperature indicator for the transformers affords the operator an easy and convenient means of

determining at the switchboard the temperature of the windings of the transformers under operating conditions. The indicator is a horizontal wattmeter, the scale of which is graduated in two-degree divisions from 20 to 130 deg.

The panel equipment is insulated from the temperature coil by means of a special insulating transformer mounted under the coil of the main transformer. The primary leads of the insulating transformer are grounded to the tank (on inside) and brought out through the cover at ground potential so that the operator is fully protected.

In order to secure accuracy it is desirable to keep the voltage which excites the bridge within 2 or 3 v. of that for which it is designed. To adjust for a change in this voltage a voltage adjusting switch is provided with steps of 5 v. from 105 to 125 v.

Three 125-kw. transformers are used for station power and are of the self-cooling, outdoor type. The fourth 125-kw. transformer designated as spare is used for station lighting.

The oil treating and drying outfit is a standard type with a capacity of 30 g.p.m. The pump is a two-stage, centrifugal direct connected to a three-phase, 60-cycle, 220-v. squirrel cage motor operating at 3400 r.p.m.

There is also a motor driven air compressor which furnishes compressed air, which is used in delivering oil from the subterranean oil tanks to the generators.

All panels for the main switchboard are made of black Monson slate, 2 in. thick.

All oil switches are electrically operated. Solenoids and motor operated mechanism are wound for 125 v. direct current. All oil switches are provided with contacts for alarm bell circuits. Rheostats are motor operated except equalizer rheostats and field rheostat for the battery charging set. Exciter motors in the power station (two present, three future) are started by means of taps on the transformers. It is impossible to close the running switch until after the corresponding starting switch has been closed and opened again, or to have more than one starting switch closed at the same time, and a definite time relay is so introduced as to require the operator to throw the running switch immediately after the starting switch is opened.

Starting and running switches for the exciter motors are solenoid operated, mounted on pipe frame work without cell partitions.

Safety Standards for Industrial Control Equipment

THE RAPIDLY increasing use of electric apparatus is focusing the attention of the public on improvements in methods of protecting persons against injury from this apparatus. In order to study the problem of safety protection the Electric Safety Conference which is made up of the U. S. Bureau of Standards, the Underwriter's Laboratory, the National Workmen's Compensation Service Bureau, and the Electrical Manufacturers, appointed a joint committee for this purpose. In January, 1921, the Electrical Safety Conference published the proposed safety standards as drawn up by this committee. This proposed standard for industrial control will form part of a more complete standard to be used in conjunction with the National Electrical Safety Code. The following is an outline of the standard. The persons to be protected are divided into three classes.

1. The operator who is a person authorized to actuate or handle manual controllers.

2. A qualified person is one familiar with the construction and operation of the apparatus and the hazards involved.

3. Other persons represent neither the operator nor the qualified persons and include both the public and the employes who are not authorized to handle or operate control apparatus.

At present there is no legislative restriction defining a qualified person, but it is probable that should an accident occur the employer would be called upon to show that he exercised care in the selection of such a person.

The apparatus itself may be divided into:

1. Self-contained manually operated controllers or the manually operated parts of any controller.

2. Controllers or parts of controllers that are located out of reach of the operator.

An automatic controller consisting of a panel having magnetic contactors mounted on it and operated by a push button would represent a combination of the two classes. The push button would be considered the manually operated part of the controller and the panel, the remote part coming under class two. In order to formulate proper rules for the protection of persons it is necessary to consider the hazards which exist. The principal hazards may be briefly stated as follows: 1. Touching live parts. 2. Arc or flash. 3. Touching hot parts. 4. Explosion of fuses. 5. Gas or dust explosions. 6. Injury from moving parts of controller. 7. Phase reversal. 8. Unexpected starting. 9. Over speed. 10. Lack of emergency stop. 11. Over travel. 12. Failure of power. 13. Overload.

Most of these hazards can be avoided by the proper design and installation of the electrical equipment. The two hazards which most often result in accident are the touching of live parts, and injury from arc or flash. The first six hazards may be guarded against by enclosure, isolation, or guarding.

Some types of control apparatus such as push button stations and drum controllers provide the requisite safety features by their construction, and are, therefore, independent of the method of installation, provided the enclosure is grounded. Other control apparatus such as large contactor panels often require protection by isolation or guarding.

The control equipment should be located so that it is readily accessible for operation, inspection and repairs. Sufficient working space should be provided about the control equipment to permit its being readily repaired or adjusted by qualified persons. This space should provide a secure footing and should be large enough to provide freedom of movement without the danger of interference from moving parts of that or other machinery.

The proposed safety code covers the subject in considerable detail and merits the careful attention of all persons interested in the manufacture or use of electrical control equipment.

Auxiliary Equipment for Elevated Water Tanks

Methods Employed to Prevent the Freezing of Water Tanks and Riser. By Charles L. Hubbard

NECESSARY precautions to be taken against freezing of water tanks and risers will depend partly upon the location of the tank, its use, and construction. In a general way, tanks in localities south of 43 deg. latitude and used for purposes where the water changes frequently, will not require special provision against freezing, except for the insulation of the connecting pipes. This 43 deg. latitude line passes through the southern portion of Oregon, south central Michigan, central New York and the southern parts of Vermont and New Hampshire. This, however, is for guidance only in a very general way, for there are great differences in conditions at the same degree of latitude, both as to temperature and wind exposure.

When the tank is used as a source of supply for a sprinkler system and there is no movement of the water, much greater care must be exercised, and it is customary to provide means for heating the water where there is danger of the temperature falling well below the freezing point for any considerable length of time. Water reaches its point of greatest density at about 39 deg. F.; after this its density decreases as the temperature falls. This results in a downward movement around the outer circumference where cooling takes place most rapidly and an upward current in the center. When the falling temperature passes 39 deg., the density begins to decrease and the directions of the currents are reversed, the cooler water rising to the top of the tank, where ice is first formed. Continued cold next causes ice to be formed on the sides of the tank, which gradually increases in thickness. A moderate coating of ice upon the sides of the tank does no particular harm, as it acts as an insulator and lessens the rate of heat loss from the water; ice at the surface is undesirable for different reasons: first, it exerts a strong outward pressure due to expansion as freezing takes place which, as the layer increases in thickness, may become sufficient to damage the tank. Furthermore, it prevents the operation of float valves and closes overflow pipes; and continued ice formation gradually reduces the capacity of the tank.

Rate of Heat Loss from Tanks

Various transmission factors are given for the rate of heat loss from tanks, according to the material and thickness of shell. For wood staves 2 in. in thickness the heat loss is commonly taken as 0.5 B.t.u. per hr. per deg. difference between the air and water per sq. ft. of exposed surface. For a 3-in. shell, this may be reduced to 0.35 B.t.u., while some authorities use a somewhat lower figure.

For steel tanks, factors are given varying from 1.3 to 1.7 B.t.u.

These are all for still air; but as minimum temperatures and high winds rarely occur at the same time, it will usually be safe to figure on still air at the lowest temperature which is likely to be experienced. In localities where low temperatures and high winds may come together, as in the lake regions, it may be necessary to increase the transmission factors somewhat. A test reported some time ago upon a steel tank near Lake Michigan showed a transmission factor of 2.66 B.t.u. per deg. difference as against an average of $(1.3 + 1.7) \div 2 = 1.5$, as previously given for still air.

In computing the heating capacity of any equipment for the prevention of freezing in work of this kind, certain considerations must be taken into account. First, water has a large storage capacity for heat, and it takes a long time to cool a large body to the freezing

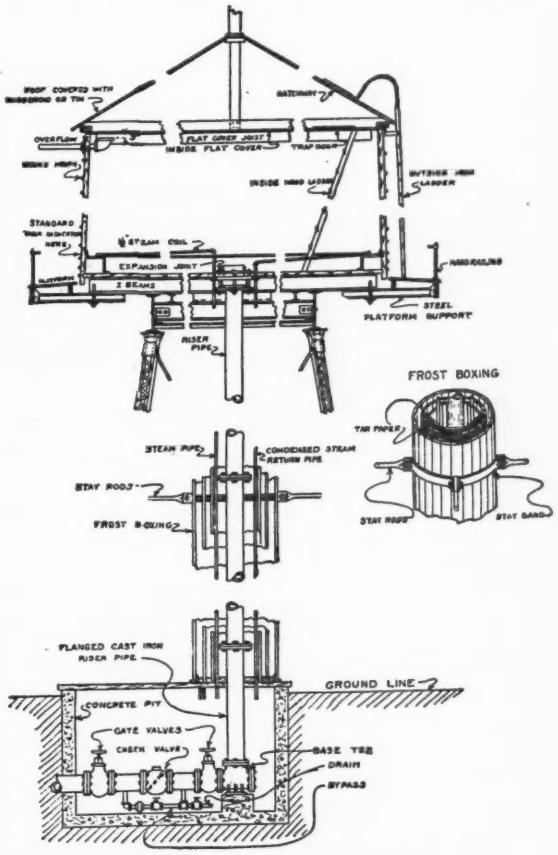


FIG. 1. PIPING CONNECTIONS FOR A SPRINKLER TANK

point, and change any considerable amount into ice. For example, each pound of water at an average temperature of 40 deg. requires the abstraction of $40 - 32 = 8$ B.t.u. to cool it to the freezing point. When freezing actually takes place, 143 B.t.u. of latent heat are given up, which goes into the air. In other words, $143 + 8 = 151$ B.t.u. must pass from the water to the air for each pound of ice formed. Again, extremely cold weather rarely lasts more than a few days at a time, while the action of the sun and changing of the water in many cases, tends to raise the temperature and overcome the effects of occasional cold periods. A fair assumption for the winter temperature of water in an outside tank, for average conditions, is about 40 deg.; hence, in falling to the freezing point, the average will be $(32 + 40) \div 2 = 36$ deg. Then with a steel tank

in zero weather, the heat transmission from water to air will be, using the higher factor, $1.7 \times 36 = 61$ B.t.u. per sq. ft. of exposed surface per hr.

A cylindrical tank 15 ft. in diameter by 20 ft. in height has an exposed area of 1294 sq. ft. and a capacity of 3540 cu. ft., and will therefore hold, when entirely filled, $3540 \times 62.5 = 221{,}250$ lb. of water.

Heat loss from tank $= 61 \times 1294 = 78{,}934$ B.t.u. per hr.

Heat abstraction necessary to cool one pound of water from 40 deg. and change it into ice equals 151 B.t.u., as previously determined. Hence, to freeze the entire body of water in the tank would require the removal of $221{,}250 \times 151 = 33{,}408{,}750$ B.t.u., and would take $33{,}408{,}750 \div 78{,}934 = 423$ hr., or nearly 18

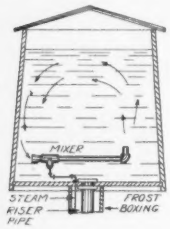


FIG 2.

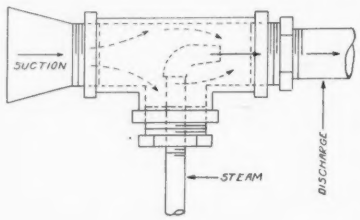


FIG 3.

FIG. 2. ARRANGEMENTS FOR BLOWING STEAM DIRECTLY INTO THE TANK WATER

FIG. 3. DETAIL OF MIXING DEVICE TO INTRODUCE STEAM INTO THE WATER

days. In case of a wooden tank, with 3-in. shell, it would require $1.7 \div 0.35 \times 18 = 87$ days to freeze solid under the same temperature conditions.

To cool the entire body of water to the freezing point would require the removal of $221{,}500 \times 8 = 1{,}772{,}000$ B.t.u. and take $1{,}772{,}000 \div 78{,}934 = 23$ hr. A layer of water 1 in. in thickness over the top of the tank contains 15 cu. ft. and weighs $15 \times 62.5 = 937$ lb. To change this from water at 32 deg. temperature into ice would require the removal of $937 \times 143 = 133{,}991$ B.t.u. and would take $133{,}991 \div 78{,}934 = 2$ hr. (nearly). Hence, to form 1 in. of ice over the surface of the water would require $23 + 2 = 25$ hr. after which it would form at the rate of about ½ in. per hr.

Prevention of Freezing

Heat, for the prevention of freezing in the tank, is provided in different ways according to local conditions. When located upon a building or near a plant where steam is available, a coil in the tank offers one of the simplest methods. In case of a comparatively shallow tank, the coil may be placed near the bottom, as shown in Fig. 1; but for those of considerable height, as compared with the diameter, it is more effective to place the heating surface nearer the top where freezing first takes place.

The rate of heat transmission from submerged steam pipes to the surrounding water will vary with the material, the position, the total temperature difference, and with conditions which affect the velocity or circulation of the water over the coil. For horizontal iron pipes in large storage tanks like those under consideration, Ehrlich gives 150 B.t.u. per sq. ft. per hr. per deg. difference in temperature, Harding and Willard 160 to 200 B.t.u. In the present example let us take the average of these, or 170 B.t.u. and assume that steam at 5 lb. pressure is to be turned into the coil for a period of 1 hr. in each 24. The average temperature of the water in falling from 40 to 32 deg. is 36 deg., and the temperature of steam at 5 lb. pressure is 228 deg., giving a difference of 192 deg. and heat transmission of $192 \times 170 = 32{,}740$ B.t.u. per sq. ft. per hr. The heat loss from the tank is 78,934 B.t.u. per hr. or $78{,}934 \times 24 = 1{,}894{,}416$ B.t.u. per day of 24 hr.

Hence, to introduce sufficient heat in one hour to prevent freezing during the following 23 hr., there will be required $1{,}894{,}416 \div 32{,}740 = 5.8$ sq. ft. of coil surface or 13 linear feet of 1¼-in. or 18 ft. of 1-in. pipe. In case brass or copper is used, multiply the surface required for iron by 0.6. The advantage of brass pipe is the smaller coil required and the absence of corrosion.

If iron is employed it should be galvanized. Figure 1 shows a tank piped for sprinkler service. The horizontal connection with the main riser is provided with a check valve allowing water to flow from the tank into the sprinkler system, but preventing it from backing into the tank under pump at city pressure. Gate valves are placed each side of the check and the tank is filled through a bypass, which also has a blowoff or drain connection as indicated. The supply and return pipes to the steam coil are carried up beside the main riser inside the frost boxing and serve to prevent it from freezing. As a further precaution, these pipes may be carried around the pit containing the check and gate valves and steam may be admitted continuously in sufficient quantity, during very cold weather, to prevent

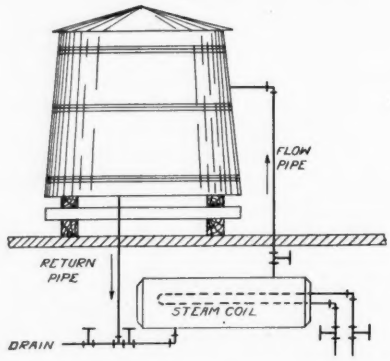


FIG. 4. INDIRECT METHOD OF HEATING TANK WATER

freezing of the pipes, even though it is not required in the tank. Whether or not this is necessary will depend upon the thoroughness with which the pit and riser are insulated. The exact method of operation will vary with local conditions, but only enough steam should be used to bring about the desired results unless there is an abundance of exhaust which is going to waste. Another form of heater sometimes used is shown in Fig. 2. In this case the steam is blown directly into the water through a mixing device shown in detail in Fig. 3. This method should only be employed with live steam free from oil, and is not recommended where the water is to be used for drinking purposes. In the arrangement shown the device is so placed as to set up a circulation within the tank approximating that indicated by the arrows.

The indirect method of heating is illustrated in Fig. 4 and makes use of a supplementary tank containing the steam coil. The location of the smaller tank with reference to the larger one will depend somewhat upon circumstances, being placed sometimes in a pent house or special housing and in others just below the roof when the main tank is supported upon a building. The latter arrangement is preferable, as it makes all parts of the apparatus accessible and easily reached for operation and repairs. The flow pipe should be well insulated to prevent waste of heat, and it may be desirable to carry it up inside the tank in some cases to reduce the exposure. Brass pipe should, in general, be used for heaters of this kind, allowing a heat transmission factor of 280 to 300 B.t.u. per sq. ft. of surface per deg. temp. difference per hr. This increase is due partly to the higher velocity of flow over the coil with this arrangement as compared with that obtained by placing the coil in the large tank.

When the tank is supported upon a tower at a considerable distance from the buildings, or where steam is not easily available, a hot-water boiler of the house-

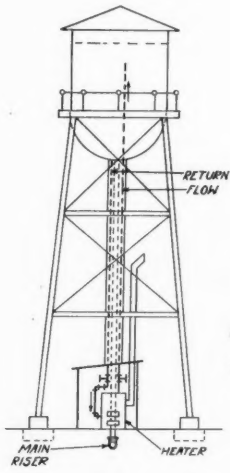


FIG. 5

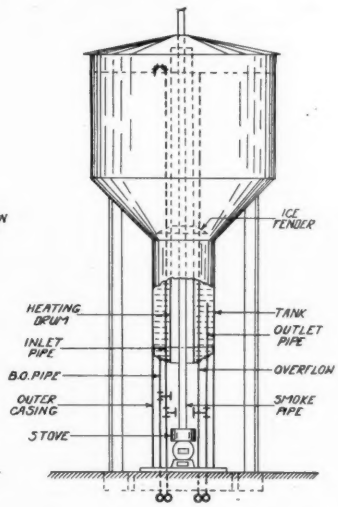


FIG. 6

FIG. 5. INDEPENDENT HEATING SERVICE FOR TANK WATER
FIG. 6. SPECIALLY DESIGNED COAL STOVE FOR TANK HEATING SERVICE

heating type may be used, placed in a small house beneath the tank, as shown in Fig. 5.

For an installation of this kind we may count upon 30,000 to 40,000 B.t.u. per sq. ft. of grate surface per hr., depending upon the attention which it receives. A heater of this type would be operated continuously, although at a reduced capacity during the night, under ordinary condition. If we allow a maximum of 40,000 B.t.u. per sq. ft. of grate for 12 hr. during the day, and one-half this, or 20,000 B.t.u. during the night, we shall have an average of 30,000 B.t.u. per sq. ft. of grate per hr. for the entire 24-hr. period. In the example given the heat loss from the tank was 78,934 B.t.u. per hr., which would call for 78,934 ÷ 30,000 = 2.6 sq. ft. of grate surface under the conditions of operation assumed. A 22-in. fire pot gives this area.

The arrangement illustrated in Fig. 6 makes use of a small coal stove in connection with a specially designed steel tank of the general form shown. The lower portion of the main supporting standard forms a small room for the accommodation of the stove and various valves. Extending from the top of this, upward through the tank, to a height well above the surface of the water, is a heating drum 18 or 20 in. in diameter through which is carried the smoke pipe. The heat

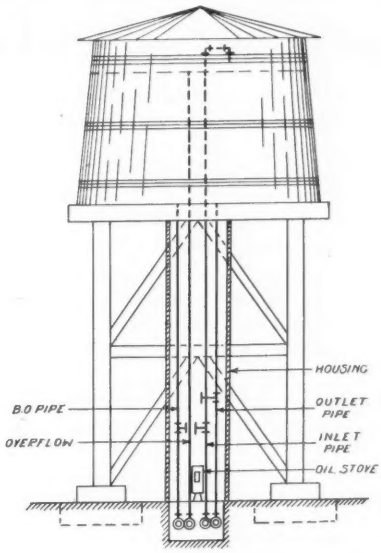


FIG. 7. PIPING INSTALLATION FOR WOODEN TANK

from the stove and smoke pipe flows upward through the drum, a portion being absorbed by the water in direct contact with the latter and the remainder passing into the enclosed space beneath the roof, warming it and preventing surface freezing. In many cases, especially with wooden tanks where heat transmission is much slower than with steel, all that is necessary in the way of heating is to prevent freezing in the pipes leading to the tank. This is frequently done by building a housing of fairly large size around the pipes, as shown in Fig. 7, using two thicknesses of sheathing with

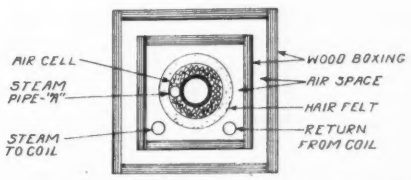


FIG. 8. METHOD OF INSULATING TANK RISERS

building paper between. The pipes are then covered with two 1-in. layers of hair felt and finished with a canvas jacket. In very cold weather this is supplemented by burning an oil stove within this space, as indicated in Fig. 7. Another plan, where only the pipe connections are to be cared for is to construct a tank similar to that shown in Fig. 6, with the water in the central cylinder or support extending to the ground. The large body of water thus exposed prevents rapid freezing and the pipes may be brought in from below through a well protected trench or pit.

There are various ways of insulating the pipes lead-

ing to elevated tanks of the general type shown in Figs. 1 and 5; a typical illustration is shown in cross section in Fig. 8. The central pipe, or riser, is first encased in air-cell covering, over which is placed 2 in. of hair felt held in place by a canvas jacket, well painted. Outside of this are two wooden boxes, giving the added protection of two dead air spaces. Hot water or steam pipes for heating the water in the tank are carried up through the inner boxing as shown. The small pipe lying against the main riser is ½ in. in diameter, connected with steam pressure at the lower end and arranged to blow directly into the atmosphere at the top. This is to be used for thawing out the riser in case of a freeze-up, by blowing steam through it.

Tendencies In the Development of Steam Generating Plants

DEVELOPMENT IN THE DESIGN, INSTALLATION AND OPERATION OF PRIME MOVERS AND ACCESSORY EQUIPMENT AS PRESENTED IN THE REPORT OF THE PRIME MOVERS COMMITTEE OF THE N. E. L. A.

WHILE no important development in steam turbine design or construction was recorded during the past year, from the experience gained in the operation of the latest designs of turbines, various changes and adjustments have been indicated and the efforts of manufacturers have been largely directed toward improvements in a number of important details affecting the reliability and operating efficiency of their units.

These changes in detail of design and construction, the establishment of a higher grade of workmanship and

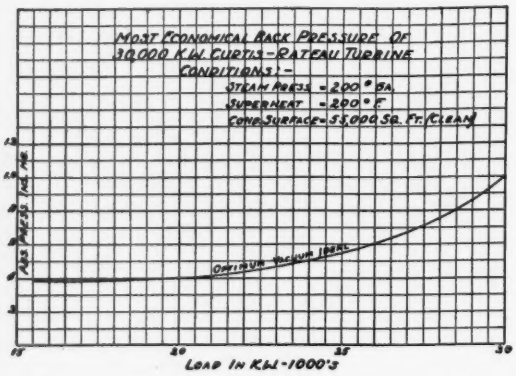

MOST ECONOMICAL BACK PRESSURE OF
30,000 K.W. CURTIS-RATEAU TURBINE
CONDITIONS:-
STEAM PRESS. - 200 # GA.
SUPERHEAT - 200° F.
COND. SURFACE - 35,000 SQ. FT. CLEAN
OPTIMUM VACUUM 10 INS.
LOAD IN K.W. - 1000'S

FIG. 1. ECONOMICAL VACUUMS FOR LOADS FROM 15,000 TO 30,000 KW. ON A 30,000-KW. TURBINE

finish, together with a better understanding on the part of operators in reference to methods of operation, have, in general, resulted in more satisfactory service.

No larger units than previously reported have been constructed, the maximum size of single cylinder units is still limited to 45,000 kw. and there has been no appreciable change during the year in steam pressures and temperatures, although it is felt that higher pressures and temperatures are a possibility for future application. The results of operation obtained in European plants where experiments are now under way should be productive of considerable information in the near future.

The study of wheel vibration has been carried forward and a definite knowledge of operating characteristics, under actual load conditions has been made possible.

Definite information regarding details of recent design of European turbines is not as yet available except for the Ljungstrom turbine. This turbine is of the reaction type, the steam flowing from the center, or shaft radially outwards, expanded between two rotors provided with blading, revolving in opposite directions and having therefore a relative speed equal to double the actual running speeds. A generator is directly connected to each rotor, the two being operated in parallel.

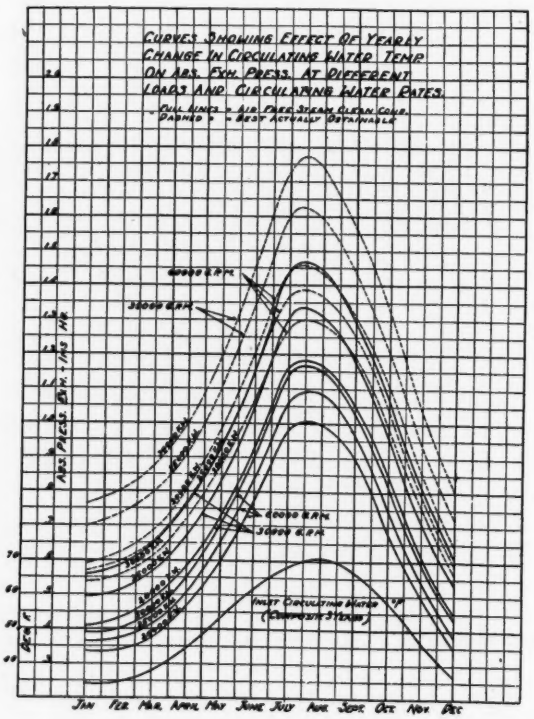

CURVES SHOWING EFFECT OF YEARLY
CHANGE IN CIRCULATING WATER TEMP
ON ABS. EXH. PRESS. AT DIFFERENT
LOADS AND CIRCULATING WATER RATES.
ABS. PRESS. EXH. - INS. HG.
JAN FEB MAR APRIL MAY JUNE JULY AUG SEPT OCT NOV DEC

FIG. 2. SEASONAL VARIATIONS IN VACUUM WITH CHANGES IN CIRCULATING WATER TEMPERATURES

Turbine lubrication is receiving a great deal of attention. On account of the severity of conditions imposed by steam turbine service and its complicated requirement the solution is difficult for both the manufacturer and the oil refiner.

As regards oil purification, the continuous system and the continuous bypass system are the most effective methods. Whatever method is used the impurities should be continuously removed, as the impurities cause the emulsification, sludging and acidity which results in rapid deterioration of the oil.

The latest development in turbine foundation is the three-point flexible suspension devised by Akimoff to

safeguard against the destructive effect of vibrations which may occur at times in any unit.

Accurate static and dynamic balancing are recognized by turbine manufacturers as being of prime importance and it is present practice to balance the individual elements before assembly and then to balance the rotor as a completed unit. Machines which have been scientifically balanced show a marked improvement in their operation.

A number of manufacturers are working on the development of a closed system of generator ventilation in which the same body of air is constantly recirculated. Such systems require, of course, that the absorbed heat be removed after each passage. Two methods of cooling

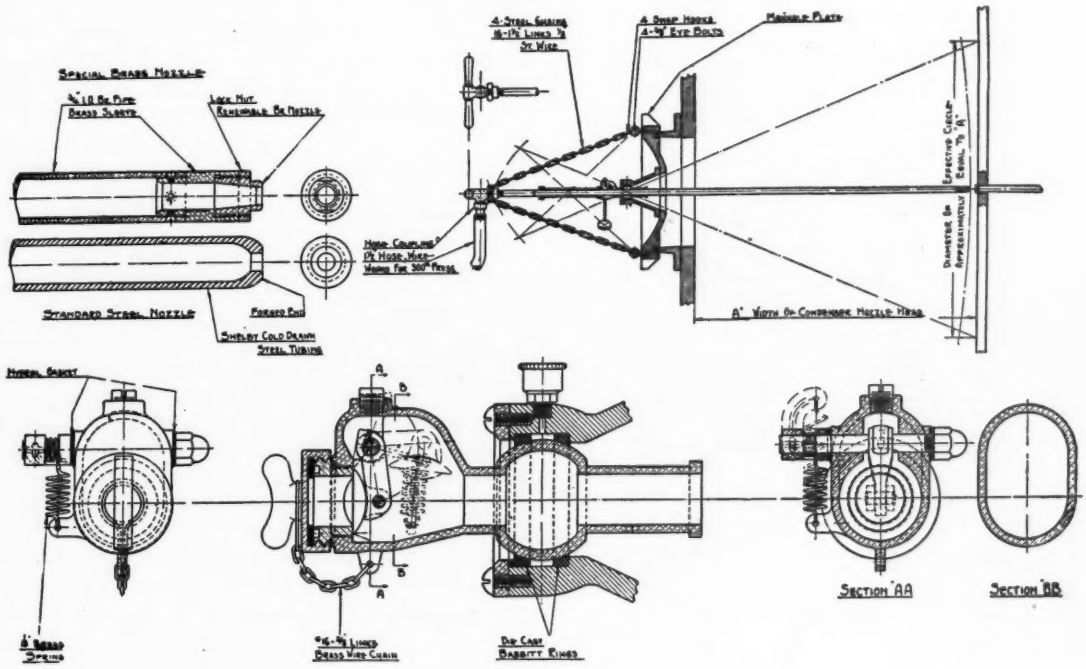


FIG. 3. DETAILS OF CONDENSER TUBE CLEANER

are available: 1, Spray cooling in which the air is passed through a dense water mist as in washing; and, 2, surface cooling in which the air passes over tubes with radiating fins, cooling water being passed through the tubes as in a surface condenser. The basic idea is to obtain cleaner air than can be obtained by washing free air and to reduce fire hazard to a minimum by having a comparatively small amount of air available to support combustion.

In connection with this system it has been suggested that the cooler might be arranged to use turbine condensate as cooling water, in this way recovering in the condensate a portion of the generator heat losses.

Condensing Equipment

The regulation of the flow of circulating water to condensers of 20,000 sq. ft. and over, taking into account the seasonal variation in cooling water temperature, is being considered by both power companies and manufacturers.

This scheme, if found practicable, will reduce the power required for driving circulating pumps and will avoid lowering the condensate to a temperature below that corresponding to the vacuum.

Two different methods of operation suggest themselves in this connection: 1. Varying the quantity of circulating water in accordance with the loading on the unit. 2. Varying the quantity of circulating water in accordance with the seasonal changes in temperature of the circulating water.

The first of these would in several ways complicate operation, especially under conductors of fluctuating loads. Possibilities with this by means of automatic regulators may exist, but this involves the use of untried equipment. The second method offers immediate possibilities and involves no radical departure from the usual practice, other than the use of variable speed circulating pumps.

Figure 1 shows the most economical vacuum for loads from 15,000 to 30,000 kw. on a 30,000-kw. turbine served by a two-pass surface condenser. Of course, in actual practice these vacuums will not be obtained even under the most favorable conditions. The effect of variation in the flow of circulating water on vacuum in the condenser equipment considered is such that the loss in vacuum below approximately two-thirds of the maximum requirements increases quite rapidly at high loads.

The seasonable conditions of the year's operations are shown in Fig. 2. The full lines represent the maximum vacuum obtainable at 60,000 and at 30,000 g.p.m. circulating water flows for loads of 20,000, 25,000 and 30,000 kw. respectively. The broken lines show the vacuum which is actually obtained under favorable conditions. To illustrate the interpretation of these curves the conditions at 30,000 kw. were taken as an example. The most economical vacuum under these conditions is

approximately 1 in. absolute. It can be readily seen from the broken line that this vacuum is actually obtainable five months out of the year with 30,000 g.p.m.

In the attempts made to secure high boiler capacities and efficiencies a great deal of attention has been given to the matter of boiler feed purification, but in many cases the matter of condenser leakage, which is of almost equal importance, has been overlooked.

In plants whose supply of raw water is not fit for boiler feed requiring extensive evaporating or treating plants, the leakage from condensers should receive particularly careful attention, for if the leakage is at all serious the expense of feed water treatment will be very materially increased.

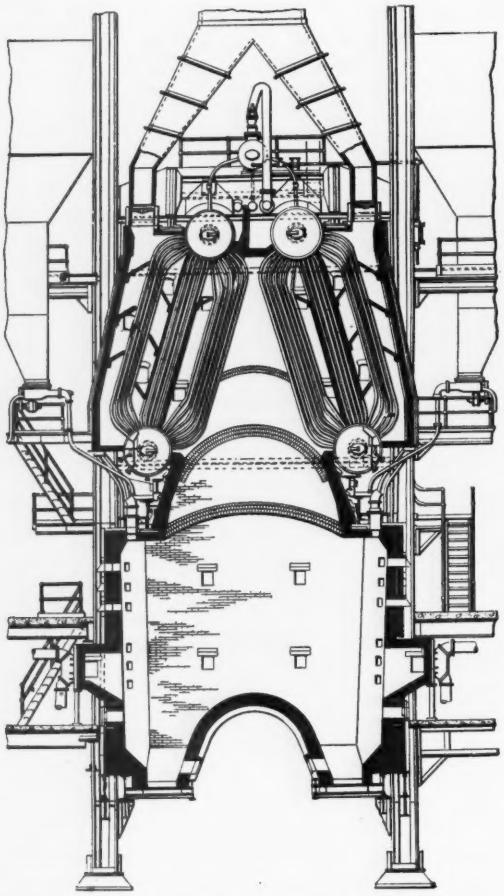


FIG. 4. CROSS SECTION THROUGH FORD BOILERS

In cases where leakage is likely to be at all dangerous various expedients have been proposed or adopted. These include expanding the tubes into one or both tube sheets or using double tube sheets with an intermediate drainage space.

The use of surface condensers has always been accompanied by the problem of keeping the tubes clean. With the increased size of units it has become increasingly difficult and expensive to take these units out of service for cleaning. With the object of keeping the condenser and its generating unit continuously in service, one manufacturer has perfected and patented a tube washing device which operates while the condenser is in service. The apparatus, which is shown diagrammatically in Fig. 3, consists of ball nozzles fitted into sockets attached to the condenser water boxes.

In condensers designed to accommodate this equipment these will be spaced about 36 in. apart and at a distance of about 36 in. from the tube sheet. The nozzle consists of a brass casting bored to receive a 1-in. steel tube lance, and is fitted on the outer end with a screwed cap for use when the nozzle is not in service. The nozzle is further provided with a spring check valve held in position by means of an adjustable spring. The lance, which is inserted through the ball nozzle which it fits, is a seamless steel tube 1 in. in diameter, drawn down at one end to form a nozzle. The other end is fitted with a hose connection which carries a collar to which are fastened four chains. These chains prevent the lance from being blown out by the force of the water. A water pressure of 250 lb. or more is required for properly cleaning a condenser, the operation consisting merely of swinging the lance about so that the water jet strikes all the tube sheet and tube ends within its range.

Boilers, Superheaters and Their Auxiliaries

A new record for the United States as regards boiler sizes was established during the past year by the installation at the Ford Motor Co. plant of four boilers each rated at 2647 hp. A cross section through one of these boilers is shown in Fig. 4. Each boiler contains 26,470 sq. ft. of heating surface exclusive of the superheater. The boilers are built to generate steam at 240 lb. gage and 200 deg. superheat. The combustion space is approximately 5 cu. ft. per hp. The furnaces are designed to burn blast furnace gas and powdered coal either separately or together. Two of these boilers operating at 275 per cent rating will be large enough to supply steam to a 30,000-kw. unit.

In addition to the tendency toward large size boilers, pressures and superheats are gradually being raised, although 300 to 350 lb. and total temperatures of 600 to 650 deg. seems to be as high as boiler designers are willing to go at the present time.

The continued high cost of economizers has led boiler manufacturers to develop a boiler with a higher tube bank to get at least part of the saving which could be realized with an economizer.

Numerous improvements have been made during the year in soot blowing equipment, and while this equipment cannot yet be considered entirely satisfactory it is generally recognized as a necessary adjunct to the modern boiler. One soot blower manufacturer reports the development of an equipment which is completely automatic and designed to blow tubes at a predetermined time, the automatic mechanism being governed by a clock-controlled electric motor. This scheme, however, has not yet had a trial under operating conditions.

On horizontal tube boilers there is a marked tendency toward the use of baffles inclined at an angle of less than 90 deg. to the tubes. The principal advantage of this type of baffle is its ready adaptation to the furnace space requirements and to the desired flue gas velocities. Several patented baffles are now on the market and member companies have reported that they are giving very satisfactory service.

The development of the Cheswick type of boiler, in which the boiler heating surface is divided into an upper

deck and a lower deck separated to give a space for the location of the superheater nearer the furnace, was a natural step brought about by the desire for maximum utilization of the radiant heat of the furnace and maximum heat absorption with minimum draft loss. A section through this boiler is shown in Fig. 5.

The large boiler units and the higher peak ratings with consequent fluctuations in rate of steaming are giving turbine manufacturers some concern because of fluctuations in superheat and consequently in the temperature of turbine parts. Several superheater manufacturers, anticipating this difficulty, are working on the design of separately fired superheaters in which superheat fluctuations are to be eliminated.

Stokers and Grates

The excessive cost of high grade coal and the consequent necessity for utilizing certain low grade coals have forced manufacturers to adapt present stoker designs to meet the new conditions. A very marked activity along these lines has been noted during the past year.

The successful application of forced draft to chain grate and conveyor type of stokers is of considerable importance because it opens up to this type a field which has heretofore been pre-empted by the underfeed stoker.

The packing and arching over of coal in stoker hoppers, resulting in irregularity of coal feed and necessitating the use of expensive manual labor for its correction, can be practically eliminated by the use of power operated agitators installed at the base of the hopper.

The successful application of a balanced draft system to control air pressure over the fire on underfeed stokers is reported by one company. The particular system used makes it possible to obtain an extremely light suction in the furnace, securing a better distribution of air and less infiltration of excess air.

On the principle that the supply of coal and air are proportional to the rate of steaming, several manufacturers are offering systems which control stoker speeds, and the speeds of fans and other auxiliaries, through a master controller actuated by difference in steam velocities. None of these systems has been in service long enough to justify their unqualified endorsement.

Various methods of preheating air of boiler furnaces have been proposed or adopted. Some of these use air ducts or channels traversing various parts of the boiler setting, and others employ special apparatus such as an air heater set in the uptake or flue. No data as to the results of operation of the various methods are available.

Economizers

The diminished incentive to use economizers on account of their present high cost is partially offset by other considerations, such as excessive coal prices, the high flue gas temperature resulting from operation at higher total steam temperatures and the fact that both economizers and fans have been greatly improved and their operation is much more satisfactory than that of a few years ago.

Relatively few changes have been made in the design features of cast-iron economizers, but manufacturers of steel tube economizers report many new developments and a number of prominent manufacturers have recently entered the field.

Considerable interest is being shown among companies in the wrought steel type on account of the higher boiler pressures now in use or contemplated, and it is probable that the respective spheres of the two types will be pretty well marked out within the next few years.

Corrosion, both internal and external, is the most serious problem which confronts the operator of economizer equipment.

Internal corrosion is due generally to the presence of excessive amounts of oxygen and CO_2 in the feed water, and it is generally agreed that where trouble is being experienced from internal corrosion one of the several existing methods must be used for freeing the air of dissolved gases.

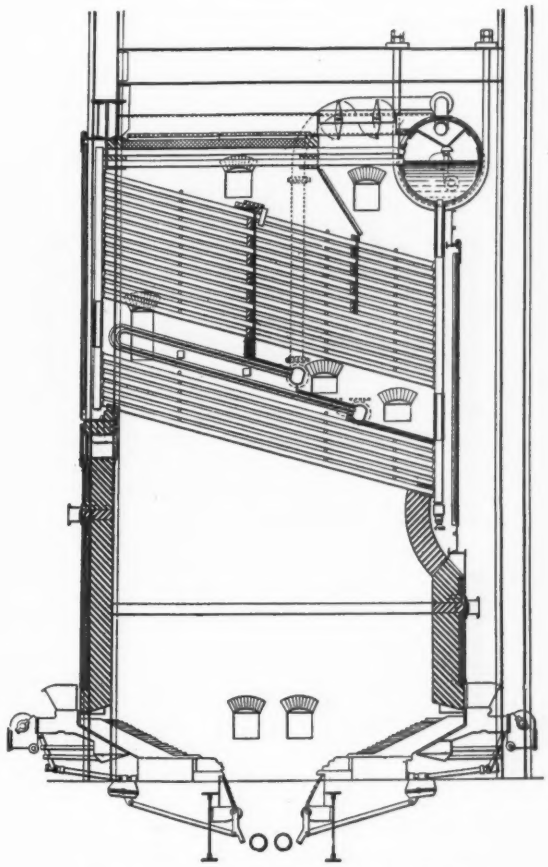


FIG. 5. THE CHESWICK TYPE OF BOILER

External corrosion of tubes is usually due to moisture condensing on the outside surface and combining with the sulphur compounds in the flue gases to form sulphurous or sulphuric acid. The remedy for this condition is to raise the temperature of the inlet water to the point where condensation does not take place under conditions of steady operation.

Great care should be exercised in the design and construction of economizers to reduce the air leakage to a minimum, and even where this is done it would probably be wise to have the induced draft fan capacity somewhat greater than theoretical allowances require if satisfactory operation is to be obtained.

Power Station Auxiliaries

It is quite generally accepted that the most economical methods of maintaining heat balance in the larger stations are the house turbine in combination with a heater condenser, and the straight electric drive with bleeding of the main units for feed-water heating.

One company in discussing the question points out that the use of a house turbine lowers the cost of auxiliary switching equipment and, what is more important, reduces short circuit currents on auxiliary circuits.

The single-stage, high-pressure, feed pump for pressures in the neighborhood of 400 lb. has been developed in England with apparently satisfactory results. In general, American manufacturers still hold to the practice of limiting pressures to 100 lb. per stage, but one

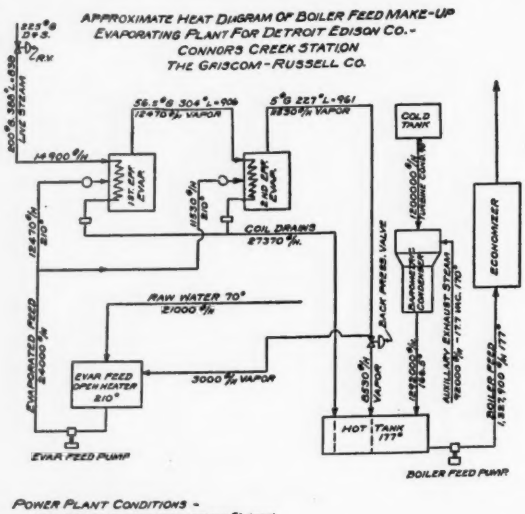

APPROXIMATE HEAT DIAGRAM OF BOILER FEED MAKE-UP
EVAPORATING PLANT FOR DETROIT EDISON CO.-
CONNOR'S CREEK STATION
THE GRISCOM-RUSSELL CO.
COLD TANK
ECONOMIZER
COIL DRAINS
RAW WATER 70°
21000 #/H
3000 #/H VAPOR
HOT TANK
177°
EVAP FEED PUMP
BOILER FEED PUMP
POWER PLANT CONDITIONS -
MAX. BOILER EVAPORATION 133,000 #/H (NET)
BOILER STEAM, 225°S (D+S)
MAX MAKE UP 21000 #/H (NET)
MAX. TURBINE CONDENSATE, 1,200,000 #/H AT 90°
EXHAUST STEAM, 92000 #/H (ASSUMED FOR TEMP OF 170°
EVAP BLOW APPROX 10000 #/24 HRS.
RAW WATER, 70° (FRESH)

FIG. 6. HEAT DIAGRAM OF CONNERS CREEK STATION

American manufacturer is now building the single-stage pump and has every confidence that it will meet all service requirements.

Station Piping

A few years ago line welds were considered advisable to reduce the number of flanged joints, but experience gained since that time indicates that they may be dangerously weak unless very carefully made.

Investigation shows that an autogenous butt weld joint is too much affected by poor workmanship to be entirely satisfactory, but there are several types in which butt welds reinforced with sleeves have proved amply strong even under the most severe conditions of service.

Practically all stations using steam above 200 lb. have standardized on steel body gate valves with complete monel metal trim.

Both hydraulically and electrically operated valves are being extensively used, a preference being shown for the electrically operated valve with the Dean type of control. There is a general demand for some type of valve which will shut off steam to the turbine steam piping, but this has not yet been accomplished.

Many companies feel that separators or water traps on steam leads to turbines are not advisable and that it is better practice to try to prevent slugs of water leaving the boilers and to depend upon well designed steam piping properly drained.

Considerable trouble has been experienced from leaking safety valves and in many cases it was found to be due to the fact that the weight of the vent piping was being carried on the valve body. A number of stations vent through a system of piping to the outside air, and even with careful designs it is difficult to prevent a portion of the weight of the pipe from being taken on the safety valve body. In many cases this trouble has been overcome by the installation of a slip joint close to the valve outlet.

Treatment of Feed Water

The high rating at which it has been necessary or economical to operate boiler plants has greatly emphasized the necessity of eliminating impurities from feed water.

The effects of bad feed water are far-reaching and a large percentage of troubles in the boiler plant are directly chargeable to this cause.

A questionnaire to companies operating evaporators for feed purification indicates that evaporator equipment, while a comparatively recent development, is successful in central station plants, provides pure water at a reasonable cost and justifies the installation and operating expense.

In connection with evaporators, Fig. 6, which is a heat diagram of Connor's Creek Station of the Detroit Edison Co., is of interest. It will be noted that the distilled water loss is small on account of the use of electric auxiliaries, and that the installation of evaporators represents a very small undertaking.

The internal use of any substances in boilers, whether for the purpose of reacting chemically or aiding mechanically in the elimination of boiler water impurities, seems to be decreasing for large plants. Except in a very few cases it will be found more satisfactory to treat the water in a separate treating apparatus rather than to carry on the reactions inside the boiler itself.

The extent to which companies are employing chemists to make periodic tests of feed-water composition is an excellent indication of the importance of clean water. Even where it is not practicable to employ a chemist, excellent results for certain purposes can be obtained from the use of portable testing outfits which can be operated satisfactorily by inexperienced men after a very little instruction.

Higher Steam Pressure

Modern plants are using high pressure steam at temperatures between 600 and 700 deg. F. At the present time lack of knowledge of the properties of materials and of the possibilities of turbine design seem to limit temperatures to a maximum not much in excess of 700 deg. F. Under these circumstances designers are considering the use of higher pressures without increasing the total temperature.

It is obvious from a review of the theoretical side of the question that real thermal improvements may be

expected, with or without a modification of the present cycle, but it is equally obvious that commercial considerations will affect the conclusions arrived at from the theoretical side.

There have been no important commercial developments leading to the use of extremely high steam pressures in this country during the past several years, but this is largely accounted for by the conditions under which industries have had to operate, leaving no room for development work along these lines. The consensus of opinion of American and European designers seems to be that 350 lb. pressure and 700 deg. F. total temperature are the upper commercial limits at the present time.

Small Steam Prime Movers

A study of the investment and operating costs of a 200-kw. small central station with various types of prime movers installed, indicates that, at all values of load factor, the lowest total cost per kilowatt-hour is realized by the Semi-Diesel engine and the condensing steam turbine, the former having a slight advantage. The difference in total cost, however, is so slight that the condensing turbine plant would be preferred on account of its lower first cost.

The calculations indicate that for a plant of this size the lower steam rate which obtains with superheated steam is, in practically all cases, offset by the higher fixed charges and increased fuel costs; and except in the case of turbines, no net gain is realized by operating the plants condensing.

Pulverized Fuel Situation

Developments in the field of pulverized fuel indicate a continued interest on the part of engineers in this method of burning coal.

The Milwaukee Electric Railway & Light Co. recently put into operation the new Lakeside plant, which will have an ultimate capacity of 200,000 kw. and which is designed for burning pulverized fuel.

Eliminating the restrictions imposed by the layout of old stations in changing over from grates or stokers to pulverized fuel equipment the question of high boiler ratings does not seem at all serious. It should be noted that high ratings are being obtained in new plants where boilers have ample combustion space and are designed expressly for burning pulverized fuel.

The whole question of burning fuel efficiently is in process of solution and no one can foresee the ultimate answer.

Burning Liquid and Gas Fuels

Present practice in the installation of fuel oil storage tanks favors the steel tank with steel roof or the concrete tank, the choice between the two being governed mainly by local considerations. The usual sizes are of 55,000, 37,500 and 25,000 bbl. capacity.

The heating of oil to secure its ready flow through piping systems makes it necessary to secure the best material and workmanship, as leakage of hot oil is dangerous and expensive.

Pipe lines must be heated as well as tanks to insure ready flow at all temperatures. Practice may be divided into two systems placing steam lines inside or outside the oil lines. Stone & Webster have provided a very unique example of the interior piping or heating arrangement at Pawtucket, fittings of which are shown in Fig. 7; Pawtucket uses 1-in. steam lines at the center of 8-in. oil lines, while at Waco, Texas, 1¼-in. lines are used inside 8-in. oil lines.

A flexible layout of oil feed and transfer piping is necessary so that troubles or accidents can be taken care of without interruption to service. Many companies have had to give this matter a great deal of study and very satisfactory layouts have been secured.

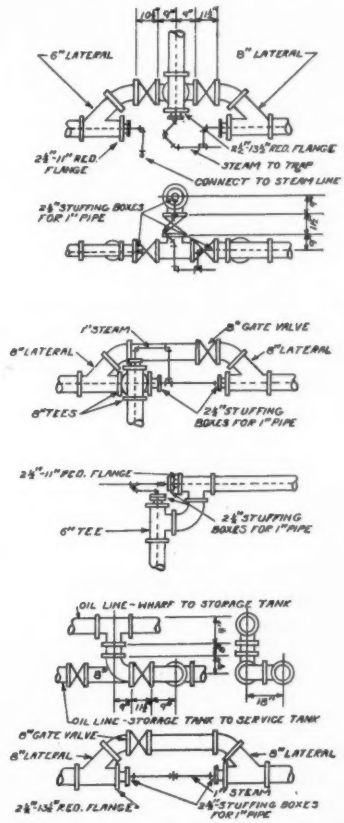


FIG. 7. DETAILS OF FITTINGS USED ON STEAM HEATED FUEL OIL LINES

There is no more important item of equipment in a fuel installation than the oil heater and very often the success of the entire system depends upon the performance of the heater.

The successful burning of oil requires that boiler designers take into account many factors other than the question of sufficient furnace volume. The type and location of baffles, location of burners, thickness and kind of refractories and a number of other equally important considerations will have a marked effect on operating results.

Convertible furnaces for a quick change from coal or other fuel to oil, when economic or operating conditions require, have been successfully employed in a number of cases.

Steam atomizing burners have been in use for a number of years in stationary plants, but it is only recently that mechanical burners have been employed to any extent. It is claimed by manufacturers that the mechanical burners use very much less auxiliary steam than do the steam atomizing burners.

This claim seems well founded and is borne out by the experience of a New England plant whose records for continuous operation over a six months' period show that only two-thirds of 1 per cent of the total steam was used by the mechanical burners.

Average boiler outputs of about 175 per cent are said to have been realized by stations using steam atomizing burners. It seems that the rating is reduced to this figure chiefly by the marked decrease in boiler efficiency at higher ratings.

On the other hand, it is claimed a boiler equipped with mechanical burners will have a very much better efficiency at high rating, and for this reason outputs of about 210 per cent of rating are secured for weeks at a time without destructive effect on brickwork or tubes.

Gases, other than natural or by-product gases, have not been used to any extent for boiler firing. In general this is due to the fact that it is more economical to burn the raw fuel if it is at all possible.

In the case of some lignites and peats which are worthless as a raw fuel but well adapted to gasification in a producer, there is room for development work to render these fuels fit for burning in the gaseous state.

The Union Gas & Electric Co. has had considerable experience in the burning of natural gas in the West End Station. This is burned during the summer when the normal demand for gas is small and under such conditions it is more economical to buy gas than coal.

The furnaces are convertible from stoker fired to gas fired and a reasonably high efficiency is secured in spite of the fact that the furnaces are designed for coal fuel.

Oil and Gas Engines

A number of manufacturers with national reputations in other lines have added the oil engine to their list of products, thus indicating their faith in the future of this type of engine for stationary service and insuring good engineering in its development.

On account of the growing demand for gasoline and lubricating oil, resulting in extensive cracking of crude petroleum, the future of the oil engine for stationary plants depends largely upon the ability of the manufacturers to develop engines which will successfully burn residues and heavy asphalt base oils.

There have been no large installations in this country operating long enough to demonstrate conclusively that these oils can be successfully handled, but manufacturers believe that their designs have already solved this problem.

Resume of Fuel Oil Situation

Oil is used for power generation or for domestic heating under two main conditions.

First: Where oil is the most efficient source of heat because of the absence of an adequate supply of cheaper fuel.

Second: Where the use of oil as fuel affords a means of using up an excess accumulation of crude oil, residues or distillates for which no other market is available.

Although the production of a sudden flood of new oil in any part of the work alters conditions temporarily, the tendency of fuel oil prices is to approximate the competitive level of coal prices, these representing the maximum for which fuel oil can be consistently sold for ordinary steam-making purposes.

Probably the most immediate influence on the price of fuel is that caused by the demand for the lighter products. This depends primarily on the requirements of automotive engines for gasoline and lubricating oil and governs the extent to which distillation or cracking is carried. Consequently the crude oil and residues available for fuel vary widely not only in quantity but also in properties and the securing of an adequate uniform supply of fuel oil is a very uncertain matter.

The opinions of authorities regarding the length of time during which our oil output can continue at its current rate with present known reserves, vary widely, but many believe that oil should be reserved primarily for use of navy and merchant ships on which the burning of coal is not practicable. In addition there is a feeling that the Government should encourage the opening up of foreign fields by American interests and should extend the same support as is given by other countries to their nationals.

In contrast to the extremely conservative and even pessimistic views regarding the future of our oil supply are the estimates of geologists as to the reserve supply of oil which can be extracted from the enormous oil shale deposits in the United States.

These estimates indicate that the supply of oil recoverable from these shales is so enormous that our present petroleum reserve is insignificant in comparison and that the United States is assured of an adequate supply of oil for all time.

It is true that with present supplies of crude oil available and under existing methods of refining, shale oil could probably not compete with the natural product, but in the event of a failure of natural supplies geologists claim that shale oil could compete in price with oils imported from foreign fields.

Senator Calder has introduced a bill in the United States Senate providing for Presidential appointment of seven commissioners, one of whom shall be the Secretary of Commerce. This commission is to study and report to the President upon the waste in utilization of the available supplies in the United States and of timber, power, transportation, oil, coal, essential minerals, and to recommend improved methods for their utilization. Further, they are to recommend measures for elimination of intermittent and seasonal production and for national waste. The commission is to serve without compensation, adopt its own plan of procedure and submit its report on or before Sept. 1, 1922.

He was the professor of physics at the African Polytechnic College.

Approaching the colored fireman at the power house, he said:

"Good morning, Moses. I would very much like to see your record of waste."

"Mah record. Say! You'se thinks I'se a waster, does yuh?"

The professor smiled at the retort, but replied:

"Not intentionally so, but all of us are more or less wasteful. Won't you please tell me where I might find the gentleman that keeps such data?"

"Nothin' doin', cause I'se thinkin' dat man might prefer keepin' dat data den keepin' mahself."

World's Largest Water Screens

INTAKE OF CINCINNATI POWER PLANT HAS THE LARGEST TRAVELING WATER SCREENS EVER BUILT. BY WALTER PAINTER

DOWN in Cincinnati there is a sign fastened close to an iron ring about two-thirds the way up a column of a bridge which spans the Ohio Rivor. At first it doesn't seem to mean much. It says:

"Tie rowboats here."

But glancing down the procession of columns you notice a line, a foot or two below the level of the ring, where the paint changes color. Then it dawns on you—you are looking at the high water mark left by Cincinnati's famous floods. Every once in a while, as in 1913 when the big Dayton flood occurred, the Ohio backs up and overflows, and every business concern in Cincinnati, below a certain elevation, goes home in rowboats to wait until the water subsides.

In 1917 the Union Gas & Electric Company at Cincinnati put two traveling water screens in the intake of their big power plant to screen the cooling water for condensers serving two 25,000-kw. turbo-generators. Behind them were two stationary screens. The traveling screens consisted of a number of closely-woven wire baskets mounted on two strands of steel roller chain operating over sprocket wheels with 51-ft. centers.

Records show that the total rise of which the Ohio River has proved itself capable is 70 ft. To take care of high water emergencies the sides of the intake wells were provided with guides, down which steel baffle plates could be dropped to block off the lower part of the intake while the screens were raised until their heads again were above water.

The tremendous quantities of refuse floated by the Ohio River during high stages, however, hindered the entirely successful operation of this plan. The large amount of silt and water-logged debris deposited at the bottom of the intake wells made it necessary to use a small crane and grab bucket to clean out the wells whenever the screens were raised to meet high water levels. Not only did the men trying to keep ahead of the mud have to work under adverse conditions, but the cost of intake labor became a rather expensive operating item.

After several conferences between engineers, an altogether satisfactory intake screening plan was developed. It called for the construction of longer water screens than had ever been known in order to cope with the 70-ft. river rise without having to be elevated. Orders

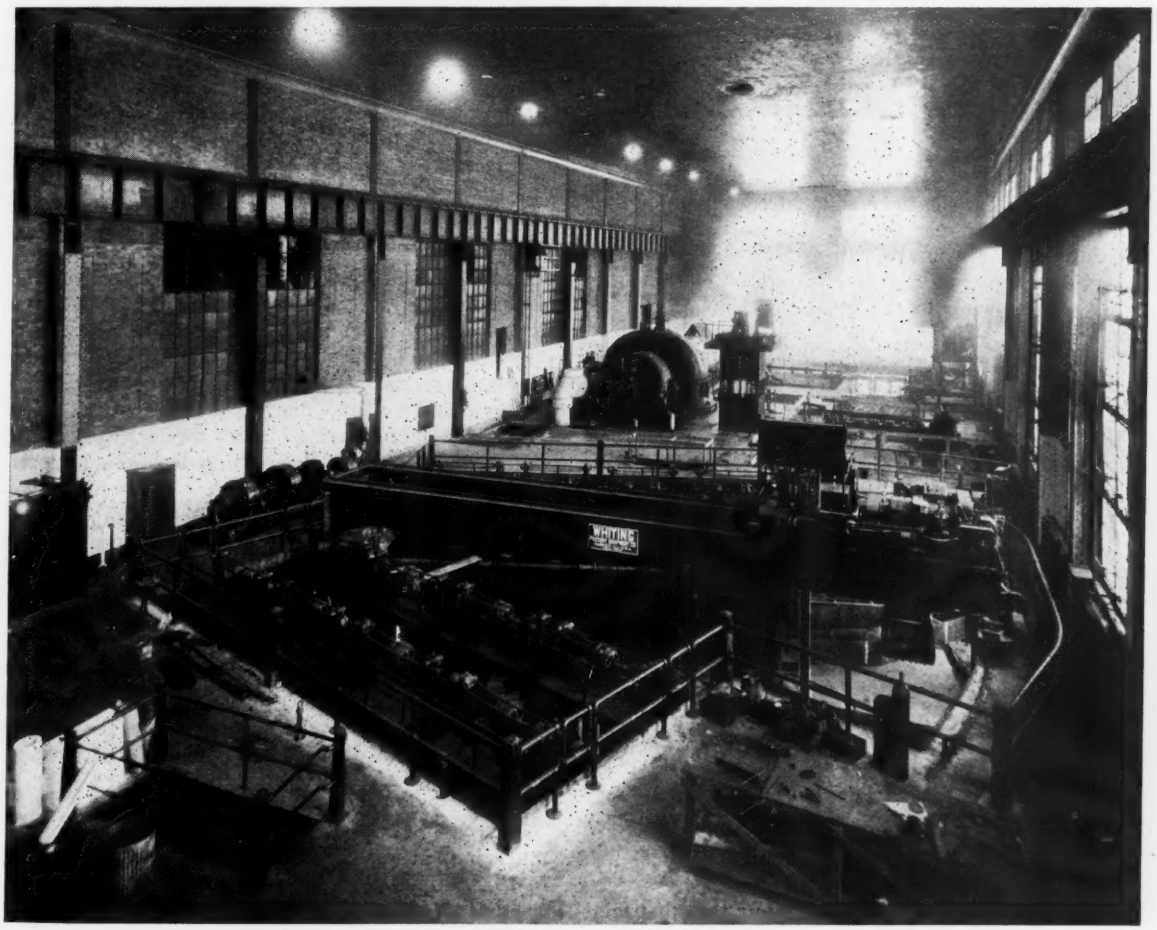


FIG. 1. TRAVELING WATER SCREENS AT INTAKE OF UNION GAS & ELECTRIC CO. PLANT

were placed for 14 new traveling screens with 91-ft. centers and for the making of two 91-ft. screens with the 51-ft. units installed in 1917.

Each of these gigantic screens is a self-contained unit, 5 ft. 8 in. wide, and is operated by a 7½-hp. motor. It has a belt of 131 traveling screen baskets formed of No. 10 galvanized wire cloth with ⅜-in. openings. All the leaves, fish, twigs, grass and other debris brought up from the murky depths of the intake are deposited in a refuse trough by a powerful spray of water directed upon the screen baskets just before beginning their downward flight.

At this plant the intake chamber, which is round and approximately 60 ft. in diameter, is situated at the center of the turbine room. As shown by an accompanying photograph, the 16 large traveling screens are arranged

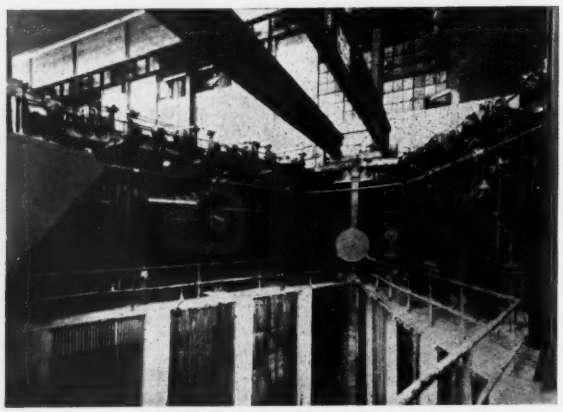


FIG. 2. BATTERY OF TRAVELING WATER SCREENS

eight on a side, each battery of eight consisting of four front-line and four rear screens. No stationary screens now are used in the intake. In making the installation the services of a diver were needed almost continuously for six weeks owing to the great depth of the intake wells.

This station now is operating three 25,000-kw. turbo-generators. Approximately 135,000 gal. per min. of clean cooling water is delivered to the three condensers. As the 16 traveling screens will yield a maximum flow of over 200,000 gal. per min., ample provision is made for the installation of future condenser units.

During flood time when the river is strewn with floating debris, or in autumn when great quantities of leaves accumulate, these screens are operated continuously, thus affording sure protection against blocked intakes and the forced shutdown of the huge turbo-generators. Ordinarily, they are placed in motion for a few minutes two or three times a day.

Watering Coal to Improve Combustion

By K. R. Long

EMPHASIS is often laid upon the deleterious effect of moisture in coal, how the purchaser buys water at the price of coal. It is absolutely true that minimum moisture content is desirable in fuel. At the same time, it is true that the addition of water to coal before it is burned—intentional watering—is beneficial for certain sizes of coal and under definite combustion conditions.

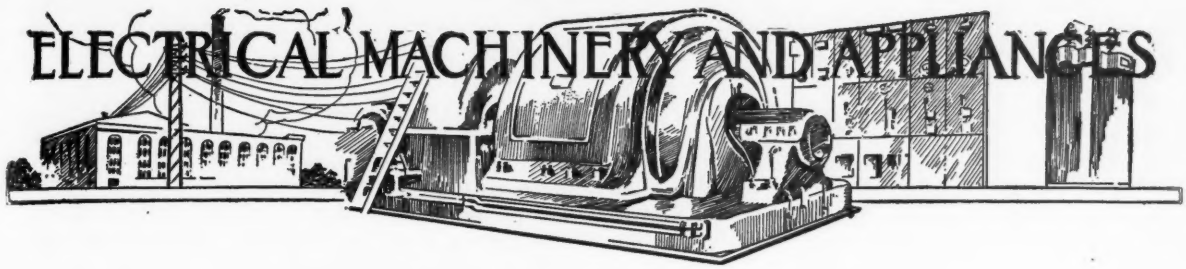
When using fines and the smallest sizes, the coal is almost invariably "wetted down" before it is fired, whether the firing is done mechanically or manually. Unfortunately the wetting down is usually an operation done carelessly and without regard to using the minimum amount of water to get the desired result. In this way, heat is wasted beyond what would be wasted in order to minimize other wastes and drawbacks.

The smaller coal sizes burn better when wetted, because the fuel bed forms a homogeneous mass, so lessening the formation of holes in the fire. With high draft intensities, less coal is blown away and there is less tendency for the uppermost strata of coal to avalanche down with certain types of stokers. The loss of unburned carbon in the ash pit tends to be less for the foregoing reason as well as because of the more uniform combustion. These are real advantages of watering; but they are obtained at a sacrifice in heat value although the loss of heat may be less than the loss due to the wastes that watering overcomes.

The heat required to separate the hydrogen of the water from the oxygen with which it is combined is exactly the same in amount as that which must be obtained by the complete combustion of the hydrogen in the furnace. Whatever hydrogen is liberated unburned up the stack represents a direct loss; it is probable that there is always a loss in this way to some degree. There is a further loss, however, regardless of the loss due to the possible escape of unburned hydrogen up the stack. When hydrogen is burned, it is transformed into water-vapor. Thus the water added to coal by "wetting down" outside the furnace is turned into steam and, as such, passes up the chimney. Heat units are called for to superheat that steam to the temperature corresponding to that of the furnace gases. Some of this heat may be utilized, as when economizers are installed, as the superheated steam is condensed and its latent heat of evaporation is used to good purpose and so the apparent loss somewhat reduced. The condensation is, in itself, corrosive and extremely so in the presence of the sulphur and carbon dioxide of the flue gases and soot. Therefore, even the absorption of heat in this way has its drawbacks.

The physical benefits of wetting down coal are greater than the chemical disadvantages. The wetting is the lesser of two evils. Therefore it is desirable that the minimum amount of water be used for the purpose. This means that men should be impressed with the need for not being too generous with the hose; they should be supervised, and instructed as to why water in excess should not be used. The saving from taking this precaution is worth while. It would pay every engineer to check up the way in which the coal is watered and ascertain whether excessive watering is not lowering the thermal efficiency of the fuel, reducing furnace capacity, hastening corrosion and wasting water.

TYPHOID FEVER was spread in South Carolina by undisciplined workmen and camp followers of the army in 1918. Since then the state authorities have reduced the disease 40 to 58 per cent in certain counties by mere sanitary education, says the U. S. Public Health Service. If there, why not elsewhere?



Protection of Industrial Circuits

METHODS AND DEVICES AND THEIR CORRECT APPLICATION. BY VICTOR H. TODD

IN THE early days of electric light and power, but little consideration was given the protection of circuits and apparatus. Motors were so inefficient that they would stop or "lie down" in the event of heavy overload; belts would often fly off in the same event; or there was usually some weak place which gave the equivalent of protection. But with the increase in efficiency and the elimination of the weak points in the system, it became necessary to provide adequate protection against many abnormal conditions such as overload, or over-

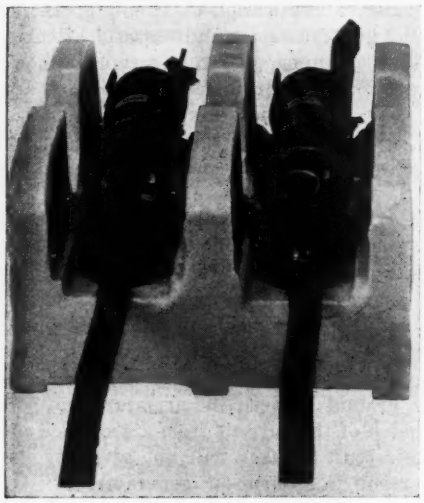


FIG. 1. LOW CAPACITY FUSES WITH FERRULE ENDS

voltage, etc., which, if allowed to exist, might cause serious damage not only to the machines and their circuits but also to surrounding material.

The protection of industrial electrical systems may be divided into four parts: (1) Protection of generators; (2) protection of motors; (3) protection of lines; and (4) protection of transformers if the system be alternating current.

PROTECTION OF GENERATORS

MANY isolated plants using either steam, gas, oil or water for their prime movers, employ direct current for their systems, as the objectionable features of low power factor are not encountered and d.c. motors are more adaptable to a variable speed than are a.c. motors.

The first step in protection is to employ a generator of sufficient capacity so that it will not be overloaded by an increase in the industrial load for many years. It is unfortunately a great temptation to add one motor after another, and one lamp after another, each addition being slight but in the aggregate totaling more than the capacity of the machine.

Provision for growth is often provided for at the switchboard and by installing extra heavy busses and cables at the preliminary installation so that one or two more generators may be added and operated in parallel should the load become too heavy in the future. Several machines in parallel also present several advantages over one large machine in that when the load is light, some of the machines may be shut down and one alone operated at a reasonable efficiency while with one large machine, it must be kept running no matter how light the load or how low the efficiency. Then, too, if one large machine becomes disabled, the entire system will be shut down while if there are several machines used in parallel, the failure of one merely means the operation of the others at an increased load with a possible curtailment of certain unimportant loads on the system.

Protection against overloads or excess currents may be obtained by either fuses or circuit breakers, the choice often being determined by the estimated sum of the initial and operating costs extended over a period of years. Fuses are the most simple and reliable means of protecting a circuit. They consist of a piece of lead or alloy wire or strip connected in the circuit in such manner that the heat of an excess current causes them to melt or "blow," thus opening the circuit. When mounted on a large slate base, with no inflammable material at hand, the fuse wire may be stretched bare between two terminals. This practice is not approved, however, as there is not only great danger of fire but anyone standing near a blowing fuse may be struck by the molten material and seriously injured.

Enclosed fuses are on the market, in which the fuse is placed in an insulating, non-burning tube such as fiber, and the fuse wire packed in heat resisting and arc suppressing powder. Up to 30 amp., the ends of the fuses are usually merely brass ferrules, which fit in corresponding jaws as shown in Fig. 1. Above this the fuse has blade ends similar to a knife switch, which also fit into suitable fuse blocks. The fire underwriters approve enclosed fuses up to 600 amp. at 250 v. and up to 400 amp. at 600 v.

All fuses should be provided with indicators to show when they are "blown." The indicator is usually a

fine piece of wire in parallel with the main fuse, run across the label, so that the blowing of the fuse leaves a scorch mark when the small wire burns out. Some fuses are refillable, but the objection to their use is that they cannot easily be provided with an indicator and some unscrupulous person may refill them with copper or heavy strip, thus giving a false sense of protection. Prices of fuses are changing daily, but a fair figure is approximately $1 per 100 amp. capacity complete with the fuse block.

Fuses vs. Circuit Breakers

Unless especially provided for, a circuit breaker will open a circuit instantly in the event of overload; but a fuse has an inherent time delay which is inversely proportional to the load. Fuses are designed to carry their rated current continuously, but will usually "blow" in from 1 to 5 min. if the current exceeds 115 per cent of normal.

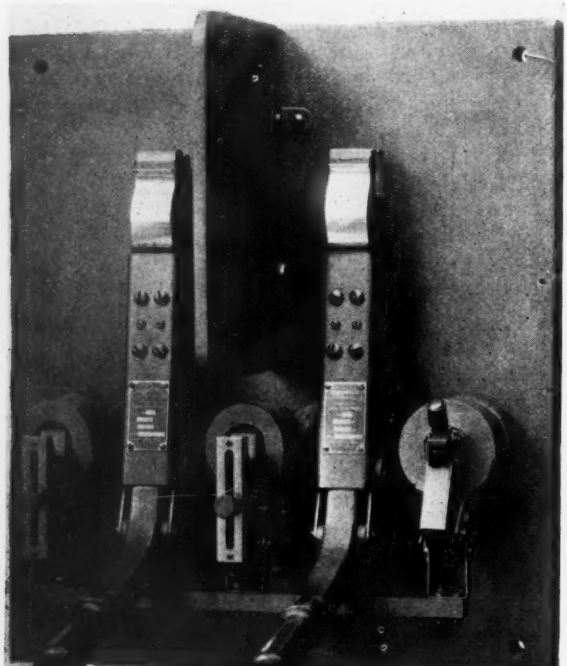


FIG. 2. TYPICAL INDUSTRIAL CIRCUIT BREAKER

On the other hand, a circuit breaker may be reset instantly while it is often difficult to locate a blown fuse and replace it. Fuses are much lower in first cost, but if the service is at all severe, the circuit breaker will undoubtedly prove the more economical in the long run. For this reason, we find some feeders, especially the smaller ones, and the ones not often subjected to overloads, equipped with fuses, while the most important feeders and the generators are equipped with circuit breakers.

Circuit breakers may take the form of carbon-break-air-circuit breakers, or oil switches. The cheaper breakers used in small installations are usually semi-automatic; that is, they open automatically but must be closed by hand. In resetting a breaker of this type, it is first necessary to open the main switch, then close the breaker and finally the main switch. Then, if the overload still exists, the breaker will again open.

The practice of holding in a breaker even with an overload on can be overcome by using the trip free breaker in which the breaker cannot be reset while the abnormal condition exists.

A third type of breaker is the full automatic in which both opening and closing is done automatically. Such breakers are usually trip free and are generally employed in large installations with a remote control board. Fuses are usually placed in series with the breaker to provide protection against breaker failure. Their use, however, is restricted in modern boards with present day circuit breakers.

There are many cases where it is not necessary to open a breaker in case of overload, as the overload disappears in a second or so. Consequently we find many installations provided with time delay attachments or protective relays, the object of which is to delay the opening of the breakers until several seconds after the occurrence of the overload. The time delay is often inversely proportional to the magnitude of the overload, thus giving the disturbance a maximum time to subside. A typical industrial circuit breaker is shown in Fig. 2.

Location of Breakers in Circuit

The point of application of circuit breakers to protect parallel generators demands careful attention, especially with compound generators serving either two- or three-wire circuits. For instance, in Fig. 3 are shown two d.c. compound generators A and B both feeding the bus C and with breakers D and E in lines opposite to the line which has the series field and equalizer connection. If the breakers were connected in these leads as in Fig. 4, then if one breaker opened all the current from one machine might flow through the series coil of the opposite machine and through the opposite breakers.

When operating a three-wire system, care must be taken to get the series fields in the leads connected to the outside legs of the circuit as shown in Fig. 5, and not to the inside as shown in Fig. 6. This figure shows a possible ground between the armature and series field and the patch of the current from a grounded neutral in which the circuit breaker will not give any protection and may result in a burnt-out generator.

When one side of a generator is permanently grounded, the circuit breakers should always disconnect the generator from all lines. The reason for this is apparent from a consideration of Figs. 7a and 7b which show the location of the breakers on both grounded and ungrounded wires and also the paths of the current in case of an accidental ground between brush and series field, the resulting short circuit current not flowing through the breaker in one case and an excess load current not flowing through the breaker in the second case.

Protection of A.C. Generators

Many times a.c. generators, especially the small sizes, are not provided with automatic protection because of their inherent characteristics of "lying-down" upon short circuit. In fact, some alternators may be shorted without serious injury and in other cases, the prime movers refuse to carry a damaging load. But while automatic protection is not necessary against actual over-

load, it is customary to guard against current reversal due to a machine dropping its load and being motored, by installing breakers with reverse power relays. Care must be taken in selecting a proper relay that it may be set for a time limit of a second or more, as if it is instantaneous, it may trip constantly due to synchronizing cross current or reverse power surges due to line switching. Reverse power relays should also function correctly even though the voltage drops to a few per cent of normal as might be the case during a heavy "short."

For actual protection of alternators against internal "shorts" which might easily cause a serious burnout, the preferred practice is to install overload relays connected differentially so that the least unbalancing of current flowing in and out of a winding will not only trip a breaker and disconnect the alternator from the line, but will also open the field, as a "shorted" coil running in an energized field will cause serious damage whether the machine be connected to the line or not. The diagram of connections of a three-phase alternator with differential protection is shown in Fig. 8.

All machines of considerable size should be provided with speed limiting devices of the centrifugal type as there is no better way to prevent a machine, either a.c. or d.c., motor or generator, from overspeeding, due to a failure of prime mover governor or motoring due to losing its field.

Protection of Circuits

From the main bus, the circuits running to the various sections of the industrial plant may be protected by either circuit breakers or fuses, according to their size and the frequency with which excessive overloads or short circuits occur. As a general rule, it is customary to install fuses on circuits up to about 100 kw. capacity, and circuit breakers on circuits above this. At this point it is judged that the constantly increasing size and cost of fuses will be greater than the initial cost of a good circuit breaker. This fact must be tempered, however, by the consideration that approved refillable fuses are now procurable, so that greater objection to fuses (i. e., high cost of replacement) is overcome, while, on the other hand, it entails a slight delay in locating and replacing the fuse, where the circuit breaker can be closed without an instant's delay.

These main feeders usually run to distribution panels located throughout the plant and from these points are run smaller feeders to the various motors. Each motor should have its own protective device either in the form of a fuse or a special device on its starter. An exception is where small fractional horsepower motors are used, where one set of fuses may be used to protect several motors whose total capacity is 660 w. or less. The fuses for a d.c. motor are usually selected of such a capacity to allow for 25 per cent overload. For example, a motor pulling 100 amp. at full load would be fused with 125 amp. fuses, as it would be considered that the motor could carry this overload safely. Alternating current motors are usually started by means of compensators giving half voltage at starting. These motors take a heavy line current at starting and consequently the fuses are not always included in the starting circuit, the protection being obtained at this period from the larger fuses at the distribution panel. This diagram is shown in Fig. 9. There are, however, at present small relays with a long time delay which are used to prevent prolonged excessive currents caused by holding the compensator handle in the starting position when the load is too heavy to be picked up by the motor.

Motors may also be protected against over and under voltage by either releases on the breakers or protective relays. Alternating current motors may be protected by relays from operating single phase on a polyphase motor and from reversed phases due to incorrect line switching or defective reconnecting in case of repairs.

Many other cases such as the sizes of wires required for given loads, the proper selection of switches and fuses, the requirements as to grounding, the location of apparatus and so forth are given in detail in the National Electrical Code which may be obtained by writing to the Underwriter's Laboratories, 207 East Ohio St., Chicago, or 135 William St., New York.

Protection from Accidental Grounds

One of the biggest problems in the operation of the industrial plant is to keep the circuits free from accidental grounds. One ground, in itself would seldom

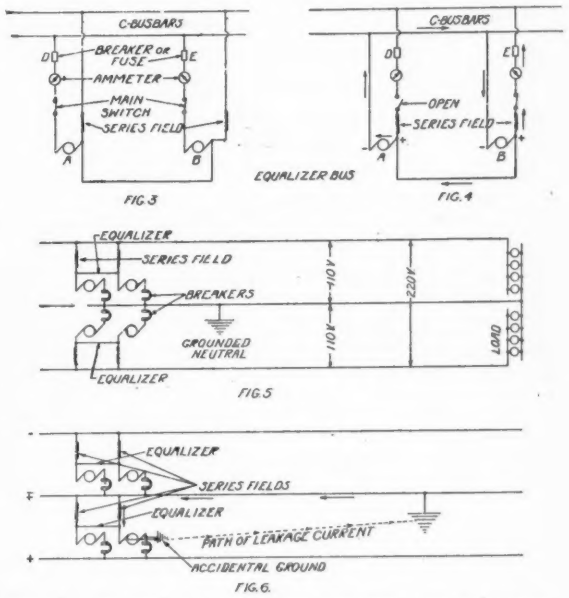


FIG. 3. CORRECT LOCATION OF BREAKERS IN PARALLEL GENERATORS

FIG. 4. SHOWING HOW CURRENT MAY FEED FROM "LIVE" MACHINE (B) THROUGH DEAD MACHINE (A)

FIG. 5. CORRECT SERIES FIELDS AND BREAKER CONNECTION ON A 3-WIRE SYSTEM

FIG. 6. INCORRECT SERIES FIELDS AND BREAKER CONNECTION ON A 3-WIRE SYSTEM

cause damage but another ground on the opposite side of the circuit might cause a dead "short" and entail a considerable waste of time before the grounds are located and "cleared." On a simple two-wire circuit, two lamps connected in series across the lines, with their middle point grounded as in Fig. 10, constitute a cheap and effective ground detector device. As soon as a ground occurs, the lamp connected to that wire goes out while the other flashes up to full brilliancy. With a three-wire system, three lamps in series are employed with the

ground connection as in Fig. 11. The combinations are as follows. Line A grounded, lamp 1 out and 2 and 3 half bright; line B grounded, lamp 1 bright and 2 and 3 out; line C grounded, all bright; all lines free, all lamps burn dim.

On a three-phase circuit, three lamps may be connected as in Fig. 12, and upon the occurrence of a ground, the lamp connected to the grounded line will go out.

On a two-phase circuit, either three or four wire, the two phases may be treated as single-phase circuits.

Protection of Transformers

A small single transformer is almost invariably protected by fuses with a capacity about 25 per cent greater than the kv.a. of the transformer. In the larger sizes, however, the development of an internal short may cause a moderately heavy current, not enough to blow the fuse immediately but sufficient to eat into the transformer insulation and eventually cause a fuse-blowing current to flow. Therefore a large transformer should be instantly disconnected in the event of an internal short and to accomplish this, it is necessary to install breakers, in one side only of a single set, but in both sides of transformers operating in banks, with either special differential relays or overload relays with a differential connection.

Protection Against Lightning

Where the industrial plant is supplied from a high-tension transmission line with the central station located miles away, the line must be adequately protected against lightning and high potential line surges. The National Electrical Code gives clear information on this subject, the chief points being the location, the sizes of wire, etc. The lightning arrester should of course be located as near as possible to the plant and should give protection to every wire in the line. In the open gap type, great care must be taken that nothing inflammable is near the arrester, as frequently the vicious arc which often follows a discharge is very destructive. In all kinds of lightning arresters, great stress is laid upon a proper ground connection and the subject of making a good ground should be carefully studied, as the whole protection depends on a low resistance path into the earth. If at all available, a good metallic ground to a water pipe system is the best, but the wires running to this ground should be free from kinks and bends; the wire must have a conductivity not less than that of a No. 6 B. & S. gage wire and should not run in an iron conduit if possible. The iron conduit offers a tremendous impedance to the high frequency lightning current.

Further protection is afforded by installing choke coils between the arrester and the plant. They offer but little impedance to the load current of ordinary frequency, but offer great impedance to the high frequency of lightning; consequently the lightning takes the easier path through the arrester and into the ground.

In conclusion, it may be said that no plant, however well it may be constructed, can be made fool proof. This fact is well borne out by a visit to many so-called

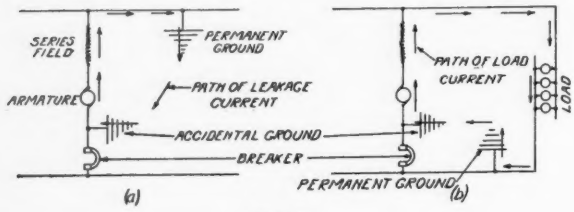


FIG. 7

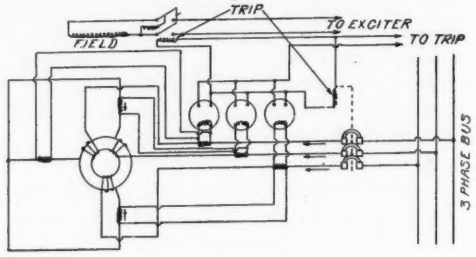


FIG 8

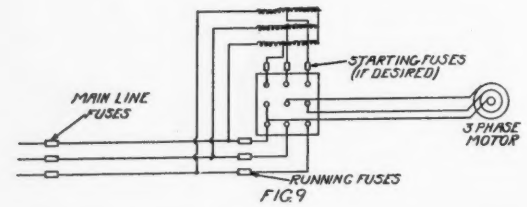


FIG. 9

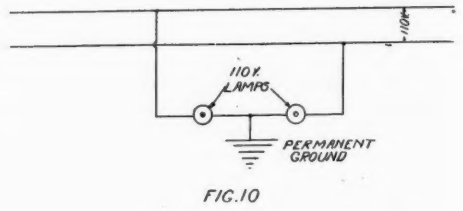


FIG. 10

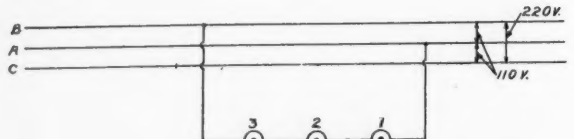


FIG. 11

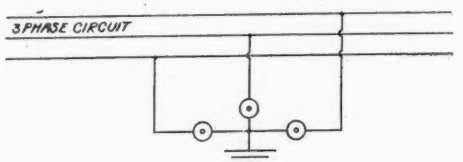


FIG. 12

FIG. 7. SHOWING WHY ONE BREAKER IS INSUFFICIENT PROTECTION FOR A GROUNDED SYSTEM. FIG. 8. DIFFERENTIAL CONNECTIONS FOR GENERATOR PROTECTION. FIG. 9. CONNECTIONS FOR STARTING AND RUNNING A 3-PHASE MOTOR. FIG. 10. TWO LAMPS AS A GROUND DETECTOR. FIG. 11. THREE LAMPS ON A 3-WIRE CIRCUIT. FIG. 12. A 3-LAMP GROUND DETECTOR FOR USE ON A 3-PHASE CIRCUIT.

"well-operated" electrical plants where it will be found that fuses have been blown and replaced with solder wire or copper wire, circuit breakers blocked in because they tripped too frequently and protective devices removed because they were too much bother to keep in order. In a plant operated this way, sooner or later a valuable machine will burn out "unavoidably" according to reports or a fire will start due to "defective wiring." The small cost of keeping competent help to maintain the protective equipment in perfect condition is not an unnecessary expense, but is a well spent insurance not only against actual loss by damage to equipment, but also against still more expensive delays due to the inability to keep the wheels of production in motion.

Ring Fire and Flash-Overs

REMEDIES FOR THE ELIMINATION OF THESE MACHINE TROUBLES WHICH FREQUENTLY BAFFLE VETERAN OPERATORS. BY W. B. DEMUTH

RING FIRE of direct-current machines is objectionable and partly avoidable, as pointed out by O. P. Forster in the Feb. 15 issue of Power Plant Engineering. Ring fire is trival compared with flash-over. It occurs on direct-current generators, motors, and synchronous converters. Flash-overs predominate with synchronous converters.

Flash-overs occur when ring fire starts an arc between brushes or when dynamic current jumps from commutator to frame (usually at the pedestal). Ring fire is merely a spark or incandescent carbon or graphite mixed with oil and copper dust carried around the commutator. Flash-over is the dynamic current from the machine itself or from the system into which the machine is feeding or from which it is being fed.

Flash-overs are far worse than ring fire, because a flash-over is virtually a short circuit across the machine at the brushes, the amount of current being determined by the resistance of the arc and the reactance of the machine. The resistance and reactance of a synchronous converter when it has lost its field is not high and the flash-over current is usually sufficient to burn off brush pigtails, and commutator taps, pit commutator segments and do damage such that turning down the commutator becomes necessary.

Railway converters of 600 and 1200 v. are the worst machines to flash over, because of the high capacity behind them, the widely fluctuating load and the high voltage between commutator segments. Keeping commutators clean, using the proper brush, setting the brushes where the armature reaction upon opening of the circuit breaker on over-load is minimum and the adjustment of the interpole shunt windings so that sudden interruption of full load does not cause excessive shifting of the commutating flux help keep these machines from flashing over.

It is the writer's experience that synchronous converters operated on lines of high resistance, as high-voltage transmission lines, are particularly susceptible to flash-over. The reason is that there is not sufficient reactance to hold the converter in synchronism, the machine tends to hunt and this combined with sudden radical load change causes flash-over. Introducing reactance in the transformer or in the high or low-voltage side of the transformer overcomes this trouble.

The synchronous converter is often over-excited so as to produce a leading wattless current and so improve the power-factor. An over-excited machine is much more sensitive to frequency or load changes than an under-excited one, and so more likely to give trouble by flashing over or "falling out of step."

Several personal experiences with flash-overs may be instructive as they show the methods of overcoming or lessening them and reducing the damage that so often follows.

A 500-kw. converter feeding a section of trolley flashed-over every day; sometimes several times a day. The load, about 600 kw., was continuous and severe, being made up of heavy freight trains hauled up a grade. The writer changed the inter-pole shunt so as to reduce the compounding and thus reduced the flash-overs by half. He then noticed that all the flash-overs occurred upon the top half of the commutator.

The hypothesis that this was due to the collection of brush dust which was swept over the commutator was correct. The dust from the lower half of the commutator fell away from the machine while that on the top half lay upon it. Frequent wiping and the use of a different brush solved the problem. Some converters are today using asbestos "wipers" to overcome this trouble.

The inter-pole shunt adjustment is one of the first things to be considered in chronic cases of flash-over. This is especially true when flash-over occurs when the machine circuit breaker opens on short circuit. Brush position should be checked, however, before making adjustments. A field-form curve is also useful and may show up the trouble more quickly than any cut and try method. The field-form curve is obtained by plotting the voltage per segment between brushes with different loads.

In another instance heavy short circuits during the switching of trains during the early morning hours when only one converter would be running caused frequent flash-overs as well as incessant opening of the main circuit breakers. This trouble was cured in an interesting manner.

Every circuit breaker has a time lag before opening, due to the inertia of the mechanisms. The time lag of the electrical circuit was less than that of the circuit breaker, so that a flash-over would occur before the breaker could open. As the characteristics of the circuit breaker could not be changed, it was decided to change the characteristics of the circuit. About 200 ft. of heavy cable was wound upon a cable drum, thus forming a reactance coil. The inductance of this coil was effective only during current change, namely whenever the load suddenly increased or decreased. Once the load was steady the inductance was zero, as direct current and not alternating current was passing through the coil. The more gradual building up of current or the increased time lag solved the trouble, and enabled the circuit breaker to be more sensitive than the machine to sudden load changes.

In another instance, severe short circuits occurred in the car barns during the early morning and late night when only one machine was running. The station was adjacent to the load and the resistance of the circuit was practically nil. A short in the barns was virtually the same as a short on the station bus bar. This situation was easily remedied by cutting out the feeders going directly to the barn and feeding through the trolley. This arrangement was equivalent to introducing a resistance, by a longer circuit, into the supply lines to the car barn. This simple remedy overcame flash-overs that usually damaged the machine, and prevented interrupted power supply.

Some of the large city electric railways and central stations have had trouble due to flash-overs for no apparent cause. Sometimes heavy loads, short circuits, opening of circuit breakers and line surges were the apparent causes. Sometimes no apparent reason could be found; and then static, potential rises, resonance and similar mysterious and somewhat intangible causes were suggested.

Whatever the cause, remedies have been found; at any rate, most of the trouble has now been eliminated by the large utilities supplying synchronous converters over high-voltage underground conductors.

One method of protecting the converter widely used today is to insert spark gaps and resistances directly at the alternating-current slip rings of the machines. These gaps are placed between phases and between each phase and ground (station ground or machine frame, but preferably both). This maintains the machine frame at earth potential and maintains a stable neutral.

On the direct-current side, electrolytic lightning arresters are installed. These connect directly to the positive or trolley brushes on the one side and to the machine frame or earth on the ground side. Potential that may tend to pile up is thus discharged immediately to earth. This has entirely overcome the once common flashing over from commutator to bearing pedestal in at least one station to the writer's knowledge.

Limiting the Damage

When a machine flashes over, the energy of the machine and often the energy of the system supplying it or into which it is feeding all are dissipated in the flash-over. This means extensive damage may be done. It is not enough, therefore, to endeavor to prevent flash-overs. Methods of protecting the machine against itself and against the system behind it are necessary. These are quite simple, cost little and in the opinion of the writer are almost infallible.

When a flash-over or breakdown of insulation in a large motor or synchronous converter occurs the current rush will either be between brushes or sections of the armature; or from armature to earth via the frame of the machine. Armature trouble can be reduced by circuit breaker adjustment.

When current rushes to the machine frame because of potential rise or flash-over it follows the path of least resistance. In the majority of cases this is through the bearing and shaft, the current puncturing the lubricating oil film. The burns that follow often necessitate new bearing metal. This trouble can be overcome entirely by installing a copper leaf brush between the shaft and the pedestal, being fastened to the latter just as are the brushes of a direct-current generator.

To cut out a machine immediately if it is in trouble, a number of companies are using what is called a flash-over relay. A better name would be an overload relay. This is connected between the machine frame, which is insulated from earth, and ground or earth as used by the station. The contacts of this relay connect with the alternating- and direct-current circuit breakers controlling the machine. The relay may have a capacity of from about ¼ to 5 amp. If anything abnormal occurs to cause a flow of current from the machine frames to earth, the relay energizes the opening coils of the circuit breakers and the machine is immediately disconnected from both alternating- and direct-current supply. This scheme of protection is being used quite extensively with large synchronous converters, units of 3000 kw. and over.

The method of insulating the machine frame may consist of merely installing the machine frame upon the concrete floor and keeping steel girders, conduit, etc., away from it; or a wooden framework may be built up, to which the frame is anchored. When machine frames are insulated from ground, special care should be employed to prevent shock. A wooden platform or rubber mat should be placed around the machine.

There are many reasons for flash-overs. Often the cause cannot be discovered. But the effect can generally be modified by reducing the danger and damage of a flash-over to the minimum.

Power Cabinet Identification System

By A. R. Herske

IN ORDER to facilitate the work of electricians and the keeping of proper equipment records, we have installed a system of power cabinet identification which might be utilized in other plants and result as satisfactorily as in our case.

In plants where there are possibly 50 or more cabinets for all classes of power distribution, considerable confusion generally arises, when an electrician explaining some defect in one of the cabinets, attempts to locate it by its position in the building. This usually means a sketch of that portion of the building showing the location of the cabinet, whereas referring to that cabinet by some predetermined symbol or numeral would immediately locate it.

Our particular plant consists of 12 buildings, lettered from A to M. An underground tunnel runs through all the buildings, in which we carry 440-v. 3-phase power in separate feeders for motor and heating load and for lighting-load, also 125-v. d.c. for various uses.

Four hundred and forty-volt primary, lighting and hot plate transformers with 110-220-v. three-wire secondary are located on the outside of each building.

There is a primary and secondary switch cabinet for each transformer, the primary generally consisting of an enclosed switch, and the secondary of a three-wire

main line fused 220-v. panel with fused branch switches controlling individual lighting distributing panels located at various points in the building.

The purpose of the secondary cabinet is to permit localization of any trouble, and to restrict it to that particular portion of the building in which it occurred. The main line fuses are for taking meter readings on the loading of the transformer.

In addition to the foregoing, each building has a main power cabinet and several subsidiary cabinets, each controlled from a switch in the main cabinet. In the power plant is a remote control oil switch controlling the main power cabinet of each building.

Where records and prints are kept of the entire distribution system, the following method of lettering the doors of each cabinet and so marking the prints will show gratifying results.

KEY

AMP	Building "A," main power cabinet.
BP—1 etc.	Building "B," power distributing cabinet No. 1, etc.
BLTP	Building "B," lighting transformer primary cabinet.
CLTS	Building "C," lighting transformer, secondary cabinet.
FL—1 etc.	Building "F," lighting distributing cabinet No. 1, etc.
GHTP	Building "G," hot plate transformer primary cabinet.
GHTS	Building "G," hot plate transformer secondary cabinet.
HDC—1 etc.	Building "H," d.c. power cabinet No. 1, etc.

Electric Drive for Blooming Mill Service

BETHLEHEM STEEL CO. DISCARDS STEAM ENGINE; RESULTS GRATIFYING. BY B. M. JONES*

FOR the first time in the history of the American steel industry, electric power has replaced steam on a large reversing blooming mill. Only two previous installations have been made, in other countries, to change from steam to electric power and in one case the steam engine was left intact for emergency purposes.

On Dec. 7, 1920, the huge steam engine, driving the 44-in. reversing blooming mill, at the Steelton plant of

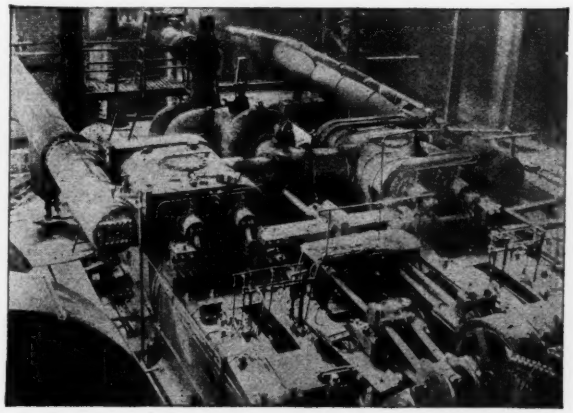


FIG. 1. TWIN TANDEM COMPOUND STEAM ENGINE REPLACED BY ELECTRIC MOTOR

the Bethlehem Steel Co., broke down. Work was started immediately to tear down the engine which, as had been previously planned, was to be replaced by electric drive. On Dec. 31, the Bethlehem Steel Co. started to roll steel with the new electric motor. Considering the tremendous task of tearing down the large reversing steam engine, blasting out its foundations, building the forms for the motor foundations and installing the complete electrical apparatus in working order, the time taken, only 24 days, is considered remarkable.

Inasmuch as the blooming mill is the only one in the plant, it was important that the change-over to the electric drive be made in the shortest time possible. In addition, it was also important that no time be lost in making adjustments or in tuning up the new equipment. To accomplish this, it was necessary to have everything well organized and planned in detail, so that there would be no unnecessary delay. The forms for the reversing motor foundation were built up complete in two pieces as a template before the engine was removed, and after the old foundation was blasted out, these templates were set in position, the foundation bolts placed, and the concrete immediately poured. This materially shortened the time required to make the change.

The motor rolled 609 tons of steel the first day, 796 the second, and 1006 the third. The mill is now operat-

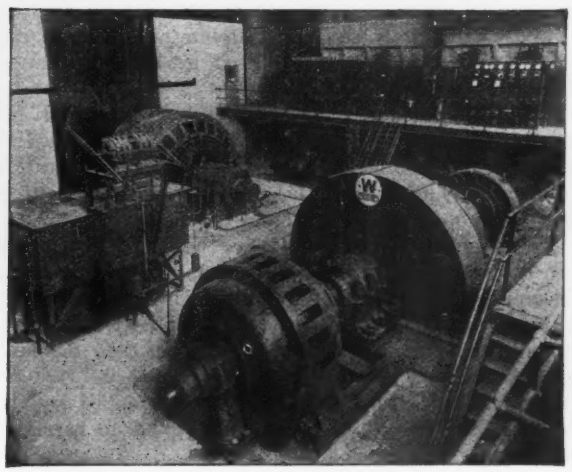


FIG. 2. BLOOMING MILL MOTOR SUBSTATION

ing single turn, and is in no way curtailing the output in spite of the fact that due to shortage of power, under the present condition it is necessary to operate the equipment with a power demand not exceeding 2500 kw.

The electric drive consists of a double unit reversing direct-current motor, the necessary flywheel motor gen-

* General engineer, Westinghouse Electric & Manufacturing Co.

erator set for driving it, and a small exciter set, together with a blower outfit and the necessary switching equipment. All the machines except the blower outfit are mounted on the first floor of the motor room substation. The blower outfit is mounted in the basement and the switching equipment is mounted on a balcony. Lightning arresters are installed on the second balcony.

The double unit reversing motor, as shown in the illustration, is a 600-v. adjustable speed direct-current machine of the compound-wound compensated type, having a speed range of 0 to 120 r.p.m. in both directions. It is capable of developing 1,900,000 ft.-lb. torque momentarily and is directly connected to the mill.

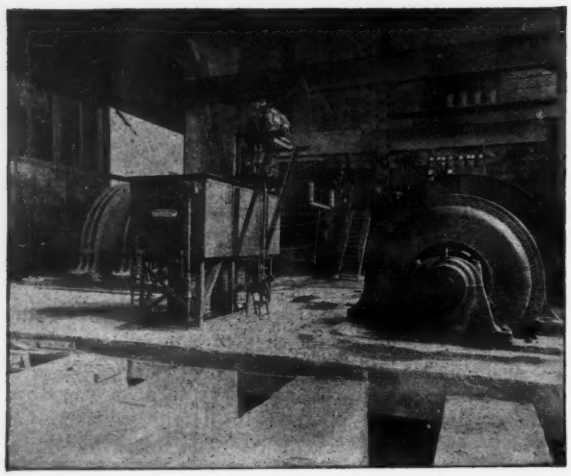


FIG. 3. GENERAL INTERIOR VIEW OF SUBSTATION

Each armature of this motor is mounted on the forged steel shaft which is supported by two pedestal bearings arranged for water cooling and gravity oil lubrication. The bearings and frame of the motor are supported by heavy cast-iron bedplate which is well anchored to the concrete foundation by long foundation bolts.

The motor is semi-enclosed and is arranged for forced ventilation. The blower equipment, installed in the basement, is interlocked so as to prevent operation of the reversing motor in case the blower is not delivering the proper amount of air to the motor.

Electrically and mechanically, the motor is designed to withstand the overloads encountered in reversing blooming mill service, and in addition it is provided with a large thrust bearing on the pedestal nearest the mill to protect it from the mechanical shocks of the mill, such as the breaking of a spindle. The ease and rapidity with which this motor can be started, stopped and reversed show it to be inherently adapted to reversing blooming mill service.

The motor is a compound-wound machine, the compounding being obtained indirectly by means of a small series exciter and a separate winding on the main poles of the reversing motor. Due to the extremely high-peak currents, encountered in the main circuit, it would be extremely difficult to reverse the ordinary type of series field which would be necessary to keep the proper shunt and series-field relation. Therefore, the series exciter and the separate field is used, the series exciter field being connected in series with the main motor armature circuit, and the armature of the series exciter being connected across the separate winding of the main reversing motor.

The switches for reversing this field are operated from the master switch, which also operates the reversing switches in the field of the generator. By this means, the compounding effect is obtained without the necessity of reversing the heavy armature current. This compounding of the reversing motor allows it to increase its torque on the overloads, and thereby better meet the severe shocks that are encountered.

Features of Motor-Generator Set

The reversing motor receives its energy from two 600-v., 367-r.p.m. separately-excited shunt-wound, direct-current generators of the compensated type, designed to withstand the same peak loads as the reversing motor. These generators are driven by a 3200-hp. alternating-current motor of the wound-rotor type, which is designed to operate on a three-phase, 6600-v., 25-cycle circuit. A 100,000-lb. flywheel is mounted on the same bedplate between the motor and generator. This flywheel is completely enclosed with a plate cover to reduce the windage losses, and also to afford protection to the operator. The flywheel bearings of this set are arranged for gravity lubrication and for water cooling as an emergency feature.

A liquid slip regulator limits the peaks and equalizes the input to the flywheel set. When the load on the alternating-current motor reaches a predetermined value, the regulator introduces resistance in the secondary of the induction motor which causes the flywheel set to slow down, thereby allowing the flywheel to give up a portion of its stored energy, and thus absorbing the peak load. When the peak load goes off, the regulator cuts out the resistance in the secondary circuit of the induction motor, and brings the flywheel set back to approximately full speed. The regulator is so arranged that the alternating-current motor cannot be started until the maximum resistance is inserted in the secondary by means of the slip regulator being wide open. The switching equipment of the alternating-current motor is so arranged that the flywheel set can be brought to rest

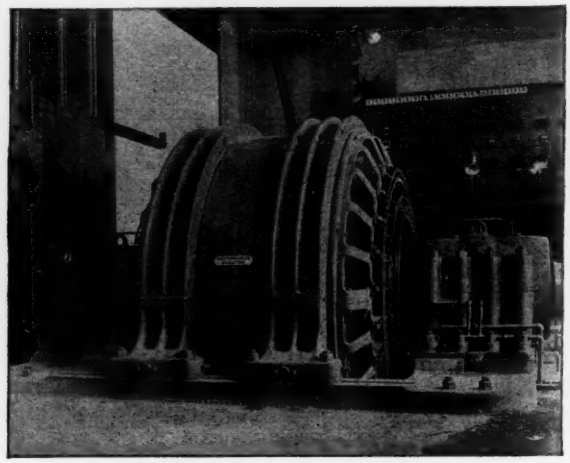


FIG. 4. SIDE VIEW 44-IN. REVERSING BLOOMING MILL MOTOR

within a short space of time by opening the forward primary oil circuit breaker and closing the reverse primary oil circuit breaker. This reverses one phase of the induction motor, causing it to exert a torque in the opposite direction, and thereby bringing the set to rest quickly.

Special attention has been given to the manner of insulating these machines to withstand the dust and dirt usually encountered in a steel plant. The direct-current machines were designed with the object in view of being able to withstand the severe overload encountered in this class of service. The rapid change of flux in the poles requires careful design to eliminate commutation troubles from which these machines are particularly free. The design of machine to handle this class of service involves many wide departures from previous practice, and the exceptional service that these machines have given is a good indication that they are liberally designed to withstand the abnormally high current encountered.

Motor Generator Control

THE SIMPLICITY of this control equipment is clearly shown by the fact that the steam engine operators rolled steel at the first trial without any trouble whatsoever. The operators seemed well pleased and surprised to find the ease with which the master switch was handled and the ready and sure response of the motor to the master switch.

Control of the main motor and generator is obtained by adjustment of the fields, the generator fields being reversed to obtain reverse direction of rotation of the main motor. The excitation of the motor shunt field remains in the same direction at all times. The speed of the reversing motor is proportional to the generator voltage up to normal voltage, and beyond that point the increase in speed of the reversing motor is obtained by weakening its main shunt field. The compound field, described previously, is adjusted to correspond with the speed of the reversing motor. The master switch is mounted in the mill for controlling the contactors which adjust the various field circuits to the motor and generators. The position of the master switch determines the speed of the reversing motor, and its direction of rotation. This system of control makes the operation of the equipment extremely simple and easy to operate, while at the same time obtaining a rapid and effective means of control. Figure 6 shows the schematic diagram of connection for this equipment.

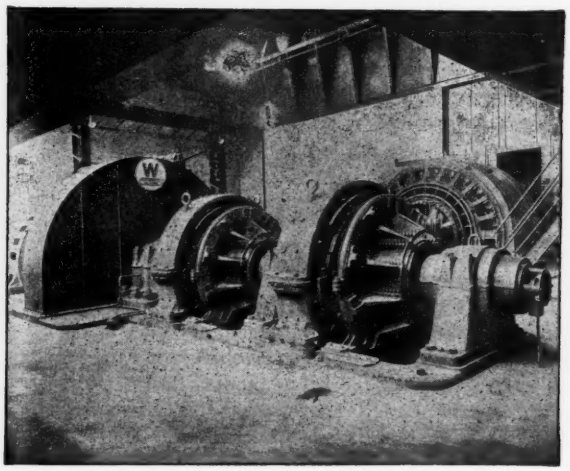


FIG. 5. FLYWHEEL MOTOR GENERATOR SET

The reversing motor and direct-current generators are separately excited, receiving their excitation from a small induction motor-driven exciter set. The main direct-current circuit breaker between the reversing motor and its generators is so interlocked that it cannot be closed unless the exciter set is operating properly.

Additional Equipment

THE MOTOR ROOM substation is used for synchronizing the two power houses and there are installed on the first three 1000-kv.a. transformers having a ratio of 2200 to 6600 v., through which the power of one power house is stepped-up to the voltage of the second power house. The oil switch and synchronizing apparatus for synchronizing these two stations is located on the gallery. A double-feeder system is brought to the gallery from one of the power plants and usually these two feeders are used in parallel for supplying the induction motor of the flywheel motor generator set.

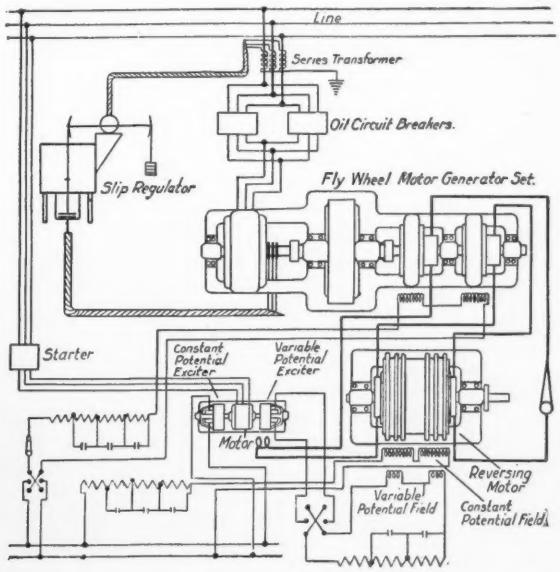


FIG. 6. SCHEMATIC DIAGRAM OF CONNECTIONS FOR DOUBLE UNIT REVERSING MILL EQUIPMENT

A small transformer, 6600 to 440 v. with a 220-v. starting tap, is used for supplying the power to the exciter set, blower and pump motors. As an emergency feature, the Bethlehem Steel Co. has brought the 440-v. alternating-current mill circuit into the motor room substation. This circuit will be used for driving the exciter set, blower and fan motors, in case any trouble develops on the small transformer.

As a convenient and effective means of keeping some of the mill dust and dirt out of the motor room substation, an additional duplicate blower equipment was installed in the basement and is arranged in conjunction with the other blower equipment, so that either blower

equipment can be used to ventilate the room while the other is ventilating the reversing motor. This affords considerable means of protection in regard to keeping dust and dirt from settling in the motor room.

This motor room substation was laid out with the object in view of installing several motor generator sets at some future date for supplying the direct-current power to the mill auxiliaries. At the present time these sets are not installed, but it is expected that they will be in operation in this substation.

Exhaust Systems

For Removal of Dust and Fumes from Workrooms: Effective Arrangements and Sizes Required

IN ROOMS where dust or fumes result from industrial operations, systems for their removal are always desirable, and in case of harmful fumes, necessary for the wellbeing of the employes. The essential parts are collecting hoods, ducts, fans, and some method of safe disposal.

For dust and heavy gases, the ducts should lead downward, and for gases lighter than air, upward, so as to take advantage of the natural flow. Where, as over vats, or machines to which access must be had with a crane, it is impossible to use overhead or enclosing hoods, lateral hoods may be necessary, but the duct should lead in an upward or downward direction according to the material to be drawn off. In all cases, the hoods should be substantial in construction, rigidly supported and never of lighter than No. 22 gage metal. Usually galvanized sheet metal is used. Heavy material should be used on grinding wheels to withstand the abrasive action of the dust and to serve as protection in case the wheel breaks. For corrosive fumes, often lead lining is used or a coating of non-corrodible paint.

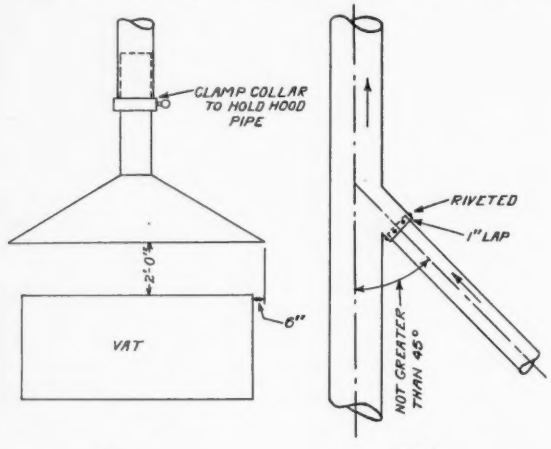


FIG. 1

FIG. 2

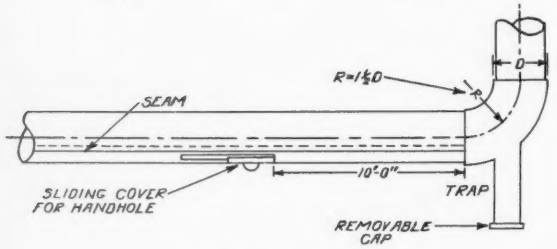


FIG. 3

FIG. 1. MOVABLE HOOD ARRANGEMENT OVER VAT
FIG. 2. METHOD OF MAKING BRANCH CONNECTIONS TO MAIN DUCT
FIG. 3. LOCATION OF SEAMS ON MAIN DUCT, ARRANGEMENT OF DUST TRAP FOR VERTICAL RISER, AND HANDHOLE COVER

To be effective, the hood should fit as closely as possible to the source of the dust or fumes, preferably enclosing it, giving access by a tight fitting sliding door. Where enclosure is impossible, the mouth of the hood should extend in every direction 6 in. beyond the machine protected for an elevation of 2 ft. above the machine; and for each additional 2 ft. elevation, the projection of the hood should be increased 6 in. in every direction. A movable hood with the attached section of pipe telescoping into the next section will sometimes prove the best arrangement, especially over vats.

Ducts

Ducts should be not less than one-sixteenth the area of the hood from which they lead, are usually of galvanized sheet metal, and should not be lighter than:

For pipe diam. in.	Gage of metal
8	24
9 to 20	22
21 to 30	20
Over 30	18

Elbows should be of metal 2 gages heavier than straight run of duct. The lines should be as short and straight as possible, with length not over 40 times the diameter. Elbows should have a radius at least 1½ times their diameter. Joints are preferably soldered to prevent leakage, loss of power and corrosion, and seams in pipe should be near the bottom, if exposed to the weather, with overlap pointing downward to shed water. All ducts should be smooth, free from dents and with 1 in. lap at the joints, the inside end pointing with the floor, to avoid collection of dust and friction loss.

Vertical risers in the run should be avoided, if possible, and when unavoidable should have a trap at the bottom of the riser to collect all material not carried up by the air, so that it can be removed. Where branch ducts lead into a main, a damper should be placed in each branch, as near as possible to the main, so that idle branches may be closed off, thus saving power. If piping passes through a fire wall there should be an automatic damper or fire door in the pipe, especially if the piping carries inflammable dust or gases.

Branches should enter the main at an angle not greater than 45 deg., the smaller the angle the better. The branch should join at the side or top of the main, never at the bottom, and connections should be staggered so that branches will not enter directly opposite each other. The branch should be riveted or soldered to the main, not depending on a slip-joint to hold it in place.

Wherever dust is likely to settle in the duct, a trap should be provided; also a handhole with tight fitting sliding cover about every 10 ft. for removing any material that may lodge in the pipe. At no place should the piping be nearer than 6 in. to a wall, floor or ceiling, so that repairs may be made easily and the outside kept clean.

Size of Duct

The size of the duct depends on the size and weight of particles, quantity of material to be moved, type and size of fan and suction needed, size of hood, and whether material comes to the system uniformly or intermittently. Large pipes are costly, but require less power to operate, though pipes too small will increase the resistance and increase power required. Some typical requirements are as follows:

Exhaust Duct Sizes

Machine	Minimum diam. of pipe, in.
Circular wood saw, 12 in. or less diam.....	4
Band saw	4
Shaper	5
Floor sweep	7
24-in. jointer	6
Grinding wheels:	
6 in. or less diam., 1 in. or less thick.....	3
7 to 9 in. diam., 1 in. or less thick.....	3.5
10 to 16 in. diam., 2 in. or less thick.....	4
17 to 19 in. diam., 3 in. or less thick.....	4.5
20 to 24 in. diam., 4 in. or less thick.....	5
25 to 30 in. diam., 5 in. or less thick.....	6
Buffing wheels:	
6 in. or less diam., 1 in. or less wide.....	3.5
7 to 12 in. diam., 1½ in. or less wide.....	4
13 to 16 in. diam., 2 in. or less wide.....	4.5
17 to 20 in. diam., 3 in. or less wide.....	5
21 to 24 in. diam., 4 in. or less wide.....	5.5
25 to 30 in. diam., 5 in. or less wide.....	6.5

For a main duct, the area of all points should equal the combined area of branches served plus 25 per cent. Enlargements should be tapered.

Fans

Either a propeller or radial blade type fan may be used, but the blades must be kept clean to ensure effective action. State regulations must always be met, but in general, an air velocity of 2000 to 2500 ft. per min. will satisfactorily move fumes, gases and light dust; for bark, chips and other heavy material, a velocity of 3000 to 5000 ft. per min. should be maintained. Tables of manufacturers will give the capacity, speed and power for their fans. In some places, two small fans, driven by a single motor will fit into an installation better than a single large fan, and will give quite as good results. The suction pipe should connect to the fan, by a detachable sleeve to give access for cleaning and repairs, the fan being on a Y branch so that the fan end of the main duct will be dead. A removable cap should be used to give access for cleaning. Discharge from the fan should be short and direct to avoid settling of dust.

Waste Disposal

Discharge should be to stacks which will carry fumes to a point where they can do no harm, to a settling chamber where dust may be deposited, to a baffle or cycle separator which will remove waste material from the air, or to a dust filter of muslin, wool or other fabric. In any case the air should be freed of all harmful material before discharge to atmosphere. Condensers are used for some fumes and dangerous gases, and in such plants great care must be taken that the apparatus is working effectively. In other plants an air washing system has proved effective in removing dust, or absorbing gases. Where the waste material has value, the cost of reclaiming it is often offset by the value of the material saved. In other cases, such as wood waste and coal gases, the fuel value is important.

Where the exhaust system draws a considerable amount of air from a workroom, provision must be made for a fresh air supply, the incoming air being filtered or washed, heated and humidified as may be necessary. As for all machinery, successful operation depends on careful inspection and upkeep to make sure that the plant is in effective operating condition.

General Operating Instructions

By W. A. Darter

IT WILL be the duty of the oiler immediately after entering upon his duties as oiler, and every hour during his shift, to inspect every oil cup, every grease cup, and every bearing that is in use, to see that they are filled and working properly. In all cases where there are troubles or parts not working normally, the oiler shall if possible, put them in normal working operation. If the trouble cannot be remedied by the oiler, then he shall report the trouble to the operating engineer working with him.

2. It will be the duty of each operating engineer upon entering upon his duties, and every hour following during his shift, to inspect all running machinery, switchboard instruments and all apparatus in use to see if the plant is operating normally and efficiently. In case of abnormal troubles that cannot be remedied by the operating engineer on duty, the engineer shall make a record, as wanted by the chief engineer, of all troubles that cannot be remedied in order that they may be attended to at the earliest possible time. The operating engineer shall also call the next operating engineer's attention to the existing trouble in order that he may know the exact condition of the plant when he enters upon his duties.

3. It will be the duty of the chief engineer upon entering upon his duties to inspect all running machinery and look into the general operating conditions of the plant to see if all parts of the power plant are running normally, and that the plant is operating at its highest efficiency. The chief engineer shall also keep a record of all abnormal running conditions, and all repairing and changing done throughout the power plant.

Operating Inspection Program of the Average Size Plant

Regular shift operating inspection of all machinery and apparatus to be made every shift by the oilers and operating engineers.

2. Regular daily operating inspection of all machinery and apparatus to be made by the chief engineer.

3. Regular weekly operating inspection of all machinery and apparatus to be made by the superintendent.

4. Regular monthly inspection is to be made by the manager of the company.

5. Regular yearly inspection is to be made by the president of the company.

Maintenance Inspection

Regular external inspection of all machinery and apparatus after each shutdown, to be made by chief engineer.

2. Regular trial inspection of all machinery and apparatus after they have been out of service a given length of time (time given on separate cards) to be made by the chief engineer.

3. Regular internal inspection of all machinery and apparatus after they have been in service a given length of time (time given on separate cards) to be made by the chief engineer.

Explanation of Inspection

This system of inspection has been successful and has in many cases reduced shutdown accidents, and as a result has saved many dollars. The superintendent's regular weekly inspection, as a check on the daily inspection, gives the chief engineer a guide to the thoroughness wanted by the superintendent.

It will be noticed that the chief engineer is held responsible for the operating and maintenance inspection. This is necessary. If two men, such as the mechanical engineer and the chief engineer, are responsible jointly, there is always something overlooked, and in case of trouble, friction is sometimes the result.

Operating Inspection Cards

The daily operating inspection cards cover each unit and apparatus in the plant, and carry a weekly inspection column for the use of the superintendent. The inspection cards also cover the trials and external inspections of all machinery not in use, in order to keep them ready for instant service.

Separate cards are also made out for each unit for periodic internal inspection. All repairs and dates of inspections are recorded on these cards. The regularity of these internal inspections depends upon the number of hours the unit has been in service. This time is taken off the daily log sheet.

The importance of regular and periodic inspections cannot be valued in dollars and cents. It comes nearer meaning the difference between failure and success of a company.

Water System Classifies Hotel Power Plant

Condition of the Water System in a Hotel Plant an Important Factor in Overall Efficiency. By George Talcott Ingersoll

WATER is an important key to the analysis of the condition of a hotel power plant. Water is the lifestream of the hotel. It goes into every room and corner of the building as steam, hot water, cold water, ice water; much of it goes under pressure and pressure costs money. A hotel without water would be about as useful as a ship without water.

Water is also the lifestream of vegetation. It goes into every part of the plant from the roots to the leaves, and it goes under pressure.

But water best suited for the lifestream of a hotel is radically different from the water best suited for the lifestream of vegetation, although the two kinds of water may look alike to the eye.

If the water for the hotel carries in solution and suspension many different minerals such as calcium, magnesium, sodium, potassium, iron, manganese, aluminum, silica, sulphur and carbonic acid, then it will make trouble and expense wherever it goes, and the longer it is used the more serious the trouble may become.

On the contrary, if the water which is the lifestream of vegetation does not contain a number of minerals in solution, then the plant cannot live and grow, for the minerals are the building stones of plants. We must not forget that the plants grow all the food for themselves and for all the animals and all the humans. It is of little use to build large hotels and industrial plants in cities unless the workers can be fed, and food must come from the farmer. We therefore look to the farmer for most of our food and if he fails to produce it, then there is another power plant problem which concerns the most wonderful power plant in the world and that is the human body. What would be poison in the lifestream of the hotel is necessary and vital food in the lifestream of vegetation.

As water is the lifestream of a hotel, it is of first importance to know all that can be learned about the water used; for it affects the boilers and engines, the valves and piping, the heaters, the pumps, the kitchen utensils, the laundry, the soap supply, and every guest.

The water supply for a hotel may come from drilled wells, lakes, or rivers. In some cities, drilled wells are used for water supply; the water from such wells is called pure water because it comes from the ground and looks clean and clear. Ask your power plant man if it is really pure water.

Pure water, H_2O, is an exceedingly rare thing, especially in cities. It may be precipitated from the cloud vapor free of impurities, but it is a natural thief and will take into solution many things in falling through the air, particularly as it nears the earth. Passing into the earth and through porous strata, it may come in contact with and dissolve varying amounts of the minerals mentioned and perhaps others, so that where well water is used, there should be an analysis made by responsible and experienced chemists of the raw water from the well, and also a separate analysis of the feed water between the heater and the boiler. The reason for the two analyses is that the water from a drilled well, particularly if an air lift is used, may, in addition to the minerals in solution, also carry in suspension silica, which is very fine sand, oxides of iron and aluminum, and also algae, a low form of plant life. If this is so, a settling tank should be used for getting rid of the material in suspension before the water goes into the boiler, for the boiler is not intended for a settling and precipitating

tank for sand, iron or clay. A water, carrying in solution a large amount of mineral matter, may, in a small boiler, deposit as much as 20 lb. or more of sediment or sludge every 24 hr. What will become of it? How much can be disposed of by blowing down? Suppose the boiler is blown down every 4 hr., how much water already heated to high temperature will be lost?

Some of the minerals above mentioned, such as the calcium and magnesium compounds, may form a hard scale inside of the boiler. About 1/16 in. in thickness of such scale may mean a loss of about 15 per cent of heat in raising the temperature of water. The more scale of this kind that is allowed to accumulate, the more expensive and troublesome is the cleanout job.

Water, carrying in solution and suspension these minerals, causes another trouble when used in hotel power plants, which may show in boilers, heaters and pipe lines, and which may make serious trouble and expense. This action is called corrosion and pitting, or electrolysis. It may be serious and should not be neglected. Heat intensifies this action.

There are certain areas in this country where water taken from drilled wells and used in boilers with steam pressure 150 lb. or more has a destructive effect on some parts of the boiler. This particular action or effect is known as caustic embrittlement. There is a considerable area in Illinois from Urbana south, where such water occurs, and the University of Illinois has made some study of the subject. Another large area occurs in south Texas and one in New Jersey.

About a hundred years ago, many grist mills and small factories in the east and south were run by the old style wood overshot water wheel. A song or a verse was written about these grist mills, the title of which was, "The mill will never, never grind again with the water that is past." Modified to suit the modern hotel, we may say: "The hotel will never run again with the water that has gone into the sewer."

It sometimes happens that water intended for the sewer does not get there; at least not by the usual route. In passing to my room in a large hotel one day, I noticed some excitement in a nearby room and learned that the bathtub had overflowed and flooded the room. Imagine, if you please, a guest safely locked in the room, has disrobed and is in the bathtub with water running, then suddenly discovers that the water could not be turned off and that there is no overflow to the tub except over the top. You may imagine also that the guest went over the top in a hurry to call for help. I was told that similar things occurred every few days. It would seem that utility and simplicity were left out in this particular design of plumbing. With a guest in a hurry, a little excitable, and not familiar with patent concealed plumbing, such accidents will occur.

To the hotel, of course, such an incident only means a room out of commission for several days, a damaged ceiling below and a lot of extra work for the help. Here, we might ask, is concealed plumbing the best for a hotel?

If the hotel buys water from a city water company, the water so taken will have a pressure of 60 lb. or more, and it will be measured by running through a meter. We have assumed that the hotel has its own water supply taken from a well, but it is equally important that it should be measured, otherwise there may be serious losses and leaks which would go unnoticed.

The chief engineer should know the quantity and cost of water taken from the well each 24 hr. It then becomes a most interesting and important task to make the distribution of this total quantity to every department using water, including the rooms or guests, under normal average conditions; he will then have a valuable check on unnecessary loss and leaks.

Little drops of water getting away constantly in a hundred or a thousand places into the sewer as leaks will in a year make a river of water. Will some one devise a type of gyroscope that will stabilize water consumption in hotels and locate leaks?

The quantity of water used in a large hotel will vary from day to day and month to month due to many causes, such as changes in weather, number of guests, kind of guests, leaks and losses, and other items, all of which affect the total. Reliable information as to average quantity used per guest each 24 hr. is hard to get; that which has come to hand shows such wide variation under approximately similar conditions that it is useless to give any figures. There must be serious losses and leaks in many hotels.

The analysis of the water, then, the quantity used, its effect on the various machines, and the number of visible leaks, give me a very interesting and important guide or clue to the overall efficiency of the plant.

A Cure-all

Do you ever get mad because you have to work? Do you ever worry because you think that perhaps you may die young? Do you just worry because you have nothing else to do? Want to be cured?

Recently, Jay Joslin, who is president of the Joslin Dry Goods Co., celebrated his 92nd birthday right at his desk in his office where he may be found every working day in the year, except for a little vacation, such as many much younger take.

Mr. Joslin says that if you want to live a long and happy life, there is only one way to do it and that is, W-O-R-K.

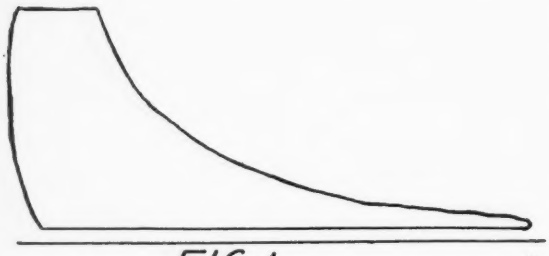
Dr. Erich W. Zimmerman, consulting economist of the United States Bureau of Mines, has submitted to Director H. Foster Bain a preliminary report on the marketability of beneficiated North Dakota lignite. The report analyzes the conditions surrounding and the difficulties affecting the fuel supply of North Dakota, South Dakota and contiguous territory. The ultimate purpose of this study is to provide the necessary economic data upon which an estimate of the commercial possibilities of beneficiated North Dakota lignite may be built up. The report specifically deals with coal production and consumption in the territory mentioned; Northwestern fuel prices; Northwestern fuel imports with special reference to their sources; the Lake coal trade to the Northwest, and the railroads and the Northwestern fuel supply.

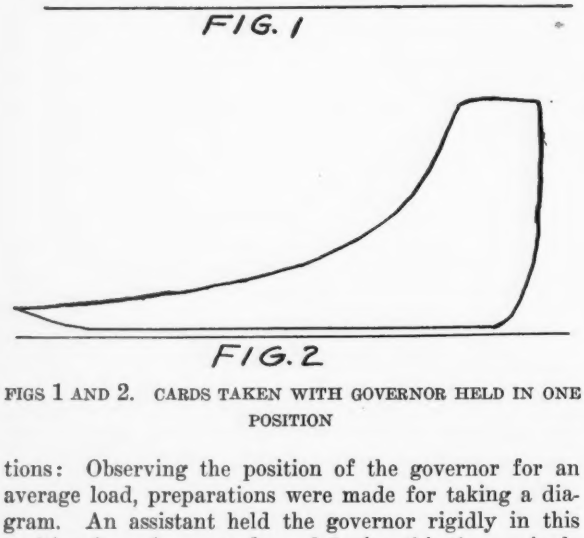
It takes 65 muscles of the face to make a frown—and only 13 to make a smile. Why waste your muscle?

Adjusting an Automatic Cutoff

ON A CORLISS engine, or any other kind that is fitted with an automatic cutoff, it is always desirable to have the supply of steam cut off at equal points in the two strokes for a stated load. Engineers sometimes claim that if a diagram is taken from one end of the cylinder, and while the load appears to be the same, another diagram is taken from the other end, they are reliable for comparison; but this is not correct, as the liability of error is too great.

The single diagrams shown in Figs. 1 and 2 were taken from a Corliss engine under the following conditions: Observing the position of the governor for an average load, preparations were made for taking a diagram. An assistant held the governor rigidly in this position for a few seconds, and during this time a single diagram was taken by an indicator that was located close to the cylinder, after which the governor was released. See Fig. 1.





FIGS 1 AND 2. CARDS TAKEN WITH GOVERNOR HELD IN ONE POSITION

The indicator was attached to the opposite end, and another diagram taken under the same conditions. See Fig. 2.

As the point of cutoff is practically the same in both cases, no improvement was attempted, but this is the only reliable way to adjust this important part when using an indicator. It is better than to use an indicator on each end of the cylinder and attempt to take both diagrams during a single revolution.

When an indicator was not available I have secured equally good results by the following method: Raise the governor to the position that it occupies with an average load and block it there. Adjust the valve gear to its running position. Draw a mark on the guides to correspond to one end of the crosshead when the crank is on either center. Turn the flywheel slowly until one cutoff valve is tripped and closed. Stop the crosshead instantly at this point, and measure the distance from the crosshead to the original mark.

Repeat the operation on the opposite stroke, and compare the points of cutoff shown. If the load is liable to be greater than the present position of the governor indicates, lengthen the shorter one until it agrees with the longer. If the load is liable to be less, then shorten the longer point of cutoff, until it agrees with the shorter.

Suppose that with a stroke of 36 in., the cutoff is set evenly at 9 in. If the load is increased until it calls for an average cutoff of about 12 in., one point of cutoff will be lengthened more than the other. If the load is made less than the above-mentioned standard, one point will become shorter than the other. This illustrates an inherent defect of these valve gears; but if set according to the foregoing directions, the difference will not materially affect the economy of the machine.

W. H. WAKEMAN.

The Application of Return Traps to Heating Systems

THE OBJECT of the writer is to show how simple it is to convert almost any heating system into a return trap system, and thus do away with 75 per cent of the care and bother which goes with the complicated systems which exist in so many plants today.

Beginning with the old time high pressure systems, of which there are many in operation; most of them with only separating traps connected to the coils, discharging out of a window, perhaps, or under the floor, and many such outfits with nothing but hand operated valves to control the drips. It is a simple proposition to install return trapping, whereby all the water of condensation can be returned to the boilers without the use of pumps, and at a temperature of from 75 to 100 deg. higher than it could be handled with a pump, and all the steam that the traps use can be carried along, after being condensed, of course, but returning to the boiler at a very high temperature, so that very little heat is lost.

The same method may be applied to the low-pressure system, which may be supplied with low-pressure steam,

or by steam at reduced pressure; or exhaust steam, or both in conjunction; but because the pressure is low, and perhaps there is little if any elevation to help, it is commonly supposed that a vacuum pump must be used in the return line to remove a part of the atmospheric pressure; and that numerous thermic valves must be installed on the coil outlets; and when they are out of order the steam passes through to the returns, and the only way a vacuum can be maintained in the returns is by the use of injection water in the pump suction. This accomplishes one thing, if nothing more: it cools the returns, thereby wasting a lot of perfectly good heat units, which the return trap system would pass along to the boiler.

In most cases, all that is necessary to change such a system to a return trap system, is to remove the thermic valves, replacing them with checks, and collect the returns, in groups, with good separating traps, and install lifting traps at the low points, and they will boost the condensate to the return trap receiver.

It is a simple matter to convert an indirect heating system, into a return trap system, if other means are employed to return the condensate; for, as a rule, it is only necessary to install separating traps, a boiler return trap, and a lifting trap if the pressure used in the coils is low.

If a vacuum system is used—by this, I mean a real vacuum system—where the pressure in the coils is lower than the atmosphere; this may also be converted to a return trap system by the use of a combined vacuum and lifting trap, of which there are plenty on the market.

During the past 10 yr., I have converted several vacuum return systems to return trap systems with great success, and a decided decrease in fuel consumption; and where reliable traps are used, such a system is very reliable, and the next thing to a gravity return system.

A strong point in favor of return trapping is the fact that the condensate from almost every steam using machine, or appliance throughout the factory, can be taken back to the boiler along with the condensate from the heating system, with little additional cost, to that of the original return trapping which is installed for the heating system.

Any practical engineer can install such a system if he will pay attention to the few points I will outline: First, the amount of water to be handled per hour must be determined or closely estimated that traps, piping, etc., may be of a sufficient size.

If the pressure on the heating coils or other apparatus is not sufficient to force the condensate to the return trap receiver, which should be located at least 4 ft. above the water line in the boiler, the low point, or points, should be located, and lifting traps of proper size should be installed at these points.

The outlet of each coil should be provided with a swing check, and it is practicable to install but one separating trap for each group of coils; for instance, if the building to be trapped is three or four stories high, it is practicable to connect the coils from each floor to a riser, or drop header, and then connect the bottom of the header to a separating trap of a suitable capacity. The condensate is then passed from the separating trap to the lifting trap, or direct to the return trap, according to the pressure maintained in the coils.

It is good policy to start a return line from the farthest point at which a separating trap is located, and continue it to the lifting trap, or to the return trap; but care should be taken that all the traps that discharge into this line do so at about the same pressure, or the expansion of the higher pressures will hold back the low ones, and in that case it is sometimes necessary to run a separate line for the low pressure returns. A good example of this is where a feed riser is trapped and the condensate is discharged into the same line with the returns from the heating coils. As a rule, the temperature of the discharge of the former trap is so much higher than that of the latter, that it flashes into steam and consequently holds back the lower temperature discharge.

It is not necessary to be as particular about grading the return lines as the supply and coils, but it helps to cut down friction. Care should be taken to get the returns large enough, and to use long turn fittings; Y's, 45's, etc., and never use a bull-head tee if it is avoidable.

It is good practice to collect all the high pressure returns in one line and let them discharge direct to the return trap and collect the low pressures in another, use a lifting trap and force them direct to the return trap. The lifting trap should in such a case be installed at the lowest point along the line of the low-pressure returns.

No doubt a good many engineers have become discouraged with return trap systems because of faulty installation or due to the fact that troublesome traps have been installed, but there are plenty of good traps on the market, which, if properly installed, will give very little trouble.

When it comes to economy, it is not at all unusual to effect a saving of 10 per cent on fuel, and a much greater saving is being effected in many plants by the use of properly installed return trapping.

L. M. Reed.

Don't Lengthen Your Wrenches

F. C. DeWeese's letter in the June 15 issue under the above title reminds me of an experience I had when I was an erector of ammonia machinery some 15 yr. ago, in California.

I didn't "lengthen my wrench" and yet I did a thing that I realize now I should not have done. Probably it never resulted in any harm; still it may have caused a lot of trouble after I left. I don't know.

In bolting a pair of ammonia flanges together, I inadvertently selected bolts that were too short. They were the correct diameter, but not long enough. They were long enough to project through the openings so that the nuts would "catch" for a distance of about a half inch. I put the nuts on and tried to draw the flanges together tightly enough so that the end of the bolt would come out flush with the nut, but "nothing doing."

So, instead of removing the bolts and getting some that were long enough, as I should have done, I applied enough force to the end of the wrench actually to stretch the bolts, bringing them up flush so that the job "looked" right. It was bad business, I felt at the time; but I was afraid of the boss, to some extent, and I didn't want him

to call me a "boob" for not selecting the right bolts in the first place, and so, at this late date, I am inclined to blame the boss.

Stretching bolts, however, is of course bad practice. No doubt I passed the elastic limit, and possibly all of the bolts were on the point of breaking, or in a very weakened condition, when I had finished with them. As soon as a rod in tension begins to reduce in area, just before rupture, its strength is very much less than normal.

All of this was done without lengthening the wrench at all. By lengthening wrenches, this same thing is often done unconsciously. There is little doubt in the writer's mind that the lengthening of wrenches has been the cause of many an accident. N. G. Near.

Using a U-Tube for a Trap

In a Western sugar refinery where much heating of tanks is done by closed coils through which is passed exhaust steam at 15 lb. pressure, a system of collecting the condensate is used where the use of traps is elimi-

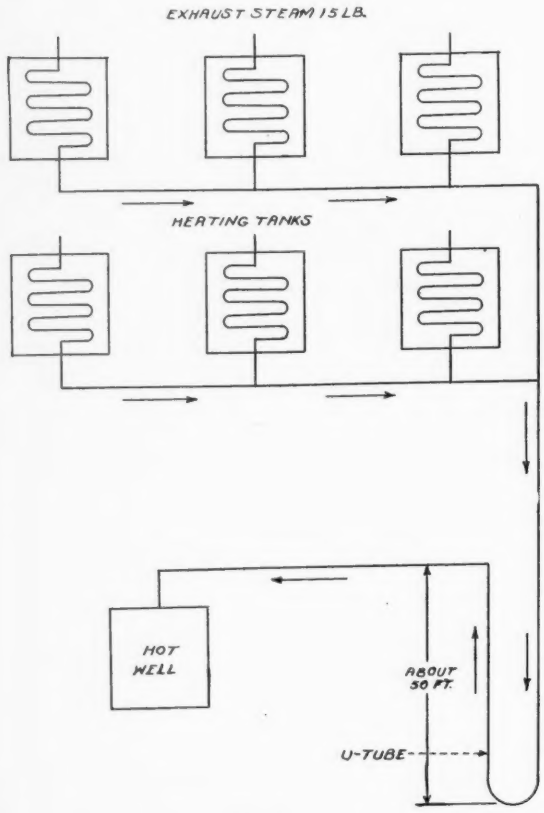


FIG. 1. DIAGRAM OF CONNECTIONS FOR U-TUBE CONDENSATE RETURN

nated. At this plant, most of these tanks are on floors at a greater height than 50 ft. from the ground.

The method used is to connect all of the outlets of the coils in these tanks to a common header and connect the outlet of the header to one side of a U-tube. This U-tube must be about 50 ft. high for an exhaust pressure of 15 lb. gage.

Marked success has been attained with the use of this apparatus and inasmuch as there are no working parts whatever in it, there has been absolutely no upkeep repairs.

In some instances it has been found to be advantageous to have the bottom of the U-tube consist of a

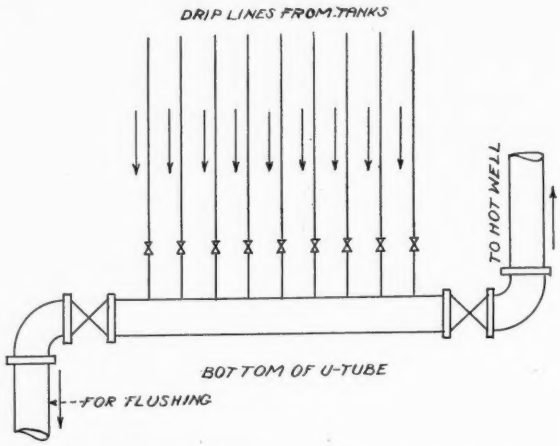


FIG. 2. HEADER USED AS LOWER RUN OF U-TUBE

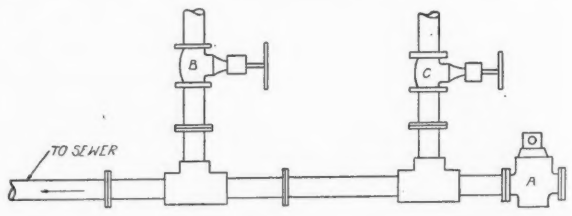
header into which the ends of the drip lines from a number of tanks discharge. At one end of this header, the line is taken off which goes to the hot well; at the other end is a valve outlet for cleaning the bottom of the tube.

Claude Brown.

Installing Boiler Blowoff Pipes

There are many different opinions as to how steam boiler blowoff pipes should be installed. When the boilers are in batteries my opinion is they should be installed so that any individual boiler connection can be taken apart and the valve or valves for that particular boiler removed without springing any pipes. Obviously this can be done only if flanges, flange fittings or unions are inside. Of course, this does not apply to cases where each blowoff pipe makes a separate line to the sewer or other receiver.

In a battery blowoff line it is a good idea to have Cock A on the end of the line. Should either B or C open into an empty boiler, when some attendant started



ARRANGEMENT OF FITTINGS IN BOILER BLOWOFF LINE

to blow down it would show at A before anybody in the empty boiler could be injured. It is understood that the cleaner will see that valve A is locked open before he goes into the empty boiler.

James E. Noble.

Lining Bearings

IN LINING a bearing it is necessary first to clean the shell, remove all old babbit or lining from shell which may be made of either iron or brass by melting it out or by chipping. Then apply heat either with gasoline torch or otherwise. When no smoke rises from the bearing, it may be said to be clean. Next, with sandpaper or file, rough up the surface so that the new lining will take hold. If the shell is brass or bronze it should be tinned all over so that the lining will take hold. If the shell is iron, it may be done the same way, by heating the shell sufficiently to melt a stick of solder when it touches the iron, but do not overheat. Next rub over the surface with a rag soaked in muriatic acid cut with zinc, which is 1 lb. zinc and 3 lb. muriatic acid. Now rub over the surface of shell with a bar of pure half-and-half solder which should melt and flow freely when applied to the hot shell. A

FIG. 1A

FIG. 1B

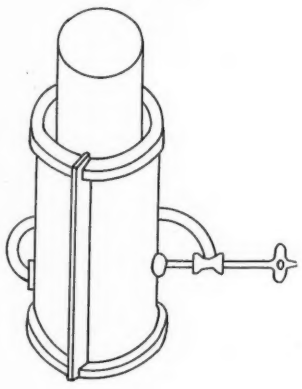


FIG. 2A

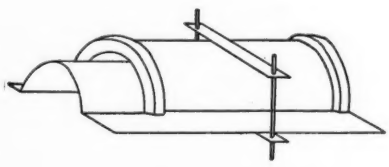


FIG. 2B

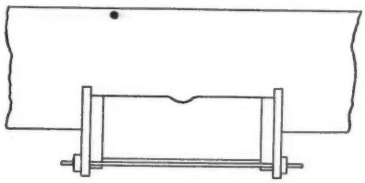


FIG. 3

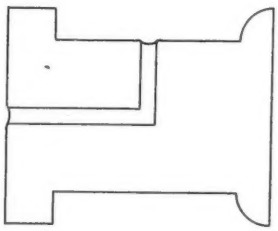


FIG. 4A

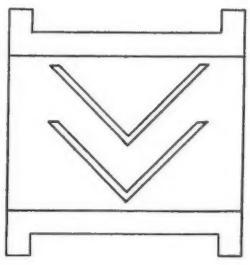


FIG. 4B

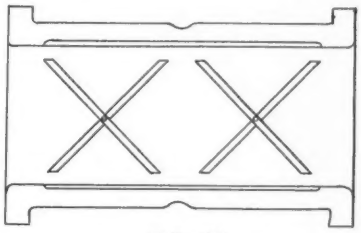


FIG. 4C

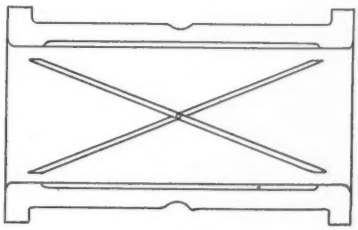


FIG. 4D

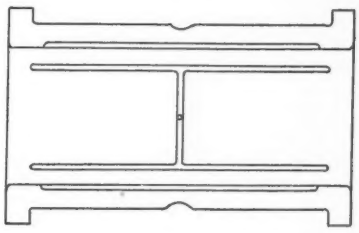


FIG. 4E

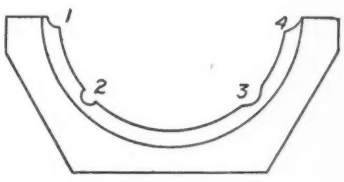


FIG. 4F

FIG. 1. LININGS HELD IN BY GROOVES
FIG. 2. USE OF MANDREL IN POURING BEARING

FIG. 3. BEARING POURED IN POSITION
FIG. 4. OIL GROOVES AND HOLES FOR BEARING

hot soldering iron will assist in covering all surface with a good coating of solder. While the solder is yet soft, rub over the surface with a dry rag to make the surface even. Tinning I consider as most important for a good job, as in all soldering. Some iron shells are not tinned because the lining is held in by slots cut or drilled in, as in Fig. 1, A and B.

Radial holes are the usual means of fastening babbit as shown at A. When ready to pour a bearing, it should be known before whether the bearing is to be bored in a lathe or scraped to a fit. If to be bored, it is necessary to use a mandrel or casting sheet ¼ to ½ in. smaller in diameter than the shaft, which allows for the extra thickness of the babbit to be removed.

If it is to be scraped to fit without boring, it should have a mandrel or casting sheet 1/16 in. to ⅛ in. smaller in diameter than the shaft. This makes less labor in fitting.

If the bearing is removable, it may be poured as shown in Fig. 2, A and B, using a mandrel clamped with wooden space sticks. Place the bearing on an iron base on its ends and dam up with putty around the bottom to make tight. Also on top dam up ¼ in. so as to round over on top for finishing. Next heat all parts until a wet finger sizzles when touched. At this moment the babbit should be all heated so that a pine stick will brown but not ignite when put in the ladle. Stir the metal well and take off all dross on top of the ladle. Pour the metal steadily without stopping. After a few seconds cool rapidly by pouring water from the bottom and work up gradually to the top of the bearing. The bearing is now ready for either boring or scraping.

If bearings are poured in position, a gasoline torch may be used to heat shaft and bearing. Means of some kind must be used at the end to dam up, such as two pieces of board cut to fit shaft, as in Fig. 3, held together with bolts and putty used to make tight, the bearing to be spaced evenly from the shaft. For a good job a piece of wrapping paper should be wound around the shaft, which delays the cooling of the babbit and loss of heat through the shaft. All that now remains is to lift out the shaft if possible and scrape to fit. If not scraped under ordinary conditions, it soon finds its seat.

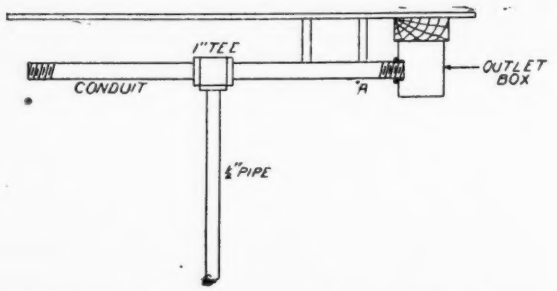
Bearings that are bored are also sometimes scraped where a good job is necessary. This may be done by evening all over the bearing surface with Prussian blue paint, or chalking is easier. Put together and move the shaft, take out and scrape high places, continuing this method until shaft bears all over. If one has not a set of scrapers, he can easily make them of old half-round files by first softening and bending to suit and grinding.

Oil grooves are next in importance for good distribution. Crankpin boxes with 2 slots, as shown in Fig. 4, B, give excellent results in spreading the oil from central feed oil hole as at Fig. 4, F, different methods being shown for boxes at Fig. 4, C, D and E. Note that bearings at end of boxes are rounding, which tends to keep the oil from throwing off as it would if box edges were sharp. A glance at Fig. 4, F, shows 1 to be the incorrect end, but at 4 to be correct. The oil groove like 2 is not so good a distributor of oil as at 3. The foregoing cases can be found to answer for some of the most extreme cases caused by bearings running at too high a temperature; but before any change of babbiting or scraping, I have saved many a job of this kind by rigid investigation to make sure that it is the babbiting job that is needed, and not misalinement, poor lubrication, filled oil grooves, or bad oil, all of which have caused many expensive babbiting jobs, to say nothing of Sundays and all night at double time for labor.

SAM BOW.

Kink in Fitting Conduit

AT ONE TIME, when I had considerable electric conduit fitting to do, I found that the ceiling in one of the buildings was quite high, making a long ladder necessary. There was only one ladder in the plant of the proper length although two were necessary, as it took two men to handle the 10-ft. lengths of conduit which was ½ in. To get out of the difficulty I hit upon the following idea. A long length of ½-in. pipe was first screwed into a 1 by 1 by ½-in. tee. Then taking the



METHOD USED TO HOLD CONDUIT IN PLACE WHILE FITTING INTO AN OUTLET BOX

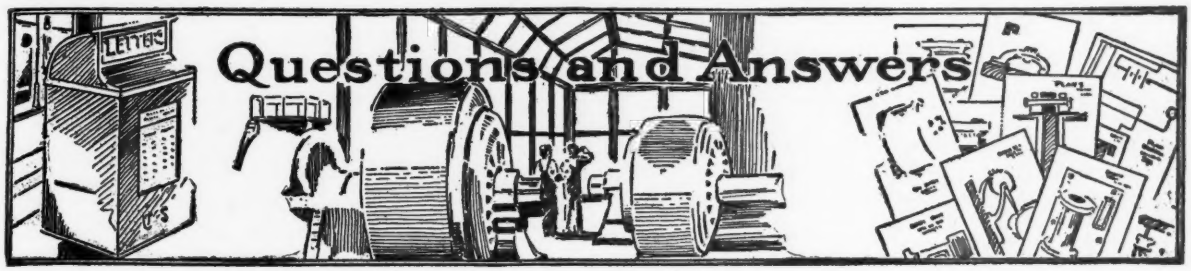
length of conduit halfway up the ladder, and then holding it so that the helper could place the tee over the conduit, I went up the ladder until I could reach the ceiling, the helper following with the other end of the conduit by raising the tee. In this manner it was an easy task to hold the conduit in position until it was placed in the outlet box and a pipe strap placed on one of the joists near the ladder as shown in the illustration at A. Then the bushing was placed and lock nut tightened. The tee was then removed from the conduit and the ladder placed in such a position that more straps could be placed over the conduit where necessary. If the conduit was to be lengthened or another outlet box to be placed, the ladder was moved to the end of the length of conduit and the same performance was gone over as before; in this way, the job was completed without any trouble.

I thought this would be of interest to some other engineer who, perhaps, has some conduit fitting to do where the ceiling is high and has but one ladder to do the work with, or the kink may come in handy at some time when fitting steam, water or air pipe.

H. A. JAHNKE.

ZEKE: "I say, Scipio, has yuh-all any idea what a heat cell am?"

Scipio: "Has I? Why, sure I has. It am dat little room where de fireman works."



Trouble Maintaining Different Temperatures

WE HAVE a hardening room and an ice tank and have trouble keeping the temperature of the hardening room low enough when working only one ice machine. The liquid seems to get to the hardening room, but the gas does not return to the machine. I understand that the difficulty is caused by the difference in temperature between the ice tank and the hardening room but would like to know how others who have similar conditions handle their plants. S. Y.

Piston Valve Engine Problem

THE ACCOMPANYING indicator diagrams were taken from the Sturtevant engine referred to in the question on valve setting on page 485 of the May 1 issue and on page 682 of the July 1 issue.

Figure 1 is the card taken before the adjustment

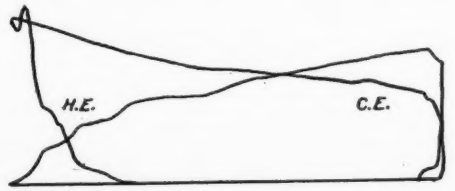


FIG. 1

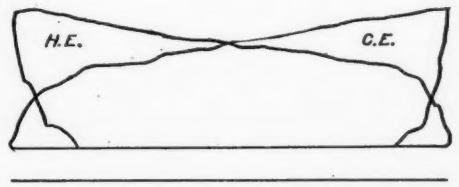


FIG. 2

FIG. 1. CARD TAKEN BEFORE CHANGES WERE MADE
FIG. 2. CARD TAKEN AFTER VALVE ROD HAD BEEN SHORTENED

was made. Figure 2 is the improved card resulting from the change made according to the suggestions in the July 1 issue. What further criticisms have you to make as to how this card may be improved?

Underground Steam Piping

IT IS MY intention to change our steam piping system between the boiler room and the main building. At present, there are two parallel lines, one 5-in. low-pressure and one 3-in. high-pressure, that run through a garage for a distance of 125 ft. and then after a 14-ft. drop are carried to the main building a distance of 65 ft. in a trench 3 ft. underground. The lines are covered with insulation all the way. The proposed change is to take them out of the ground between the garage and main building and carry them overhead at a height of 13 ft. The insulation would consist of one layer of 85 per cent magnesia, one of hair felt and a covering of tar paper which will be painted. For six months of the year the temperature varies anywhere from 5 deg. below to 50 above. Would this change be advisable?

P. M.

A Peculiar Case of Trouble with a Semi-Diesel Engine

SEVERAL MONTHS ago, we had some trouble with a 100-hp. Semi-Diesel vertical oil engine at our plant which was of peculiar nature, in fact, I have been unable to learn of anyone else having trouble of the same kind with this class of engine. If any of the readers of Power Plant Engineering have had a similar experience I would be glad to hear from them.

One night last October, I was called to the plant, the operator stating over the phone, that number one cylinder was pounding heavily. Upon my arrival at the plant

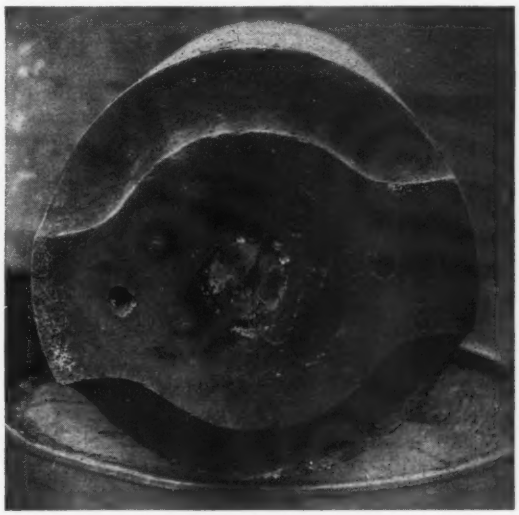


FIG. 1. CRACK DEVELOPED IN CYLINDER HEAD

it was an easy matter to tell that something was radically wrong, as the sound was as though the cylinder head would go off at any time. The cylinder was extremely warm. I opened the drain cock to the crankcase; this was a two-cycle engine, with pre-compression in the crankcase, and at every revolution fire would be blown out. My first thought was broken piston rings, and second, a broken piston.

The engine was shut down and the head taken off when it was immediately discovered that there was a hole in the top of the piston about ¼ in. wide and about 1½ in. long, permitting the explosion to be blown down through into the crankcase. The hole was similar to the one shown in the top of the piston in the accompanying photograph, except that it was wider and not quite so long.

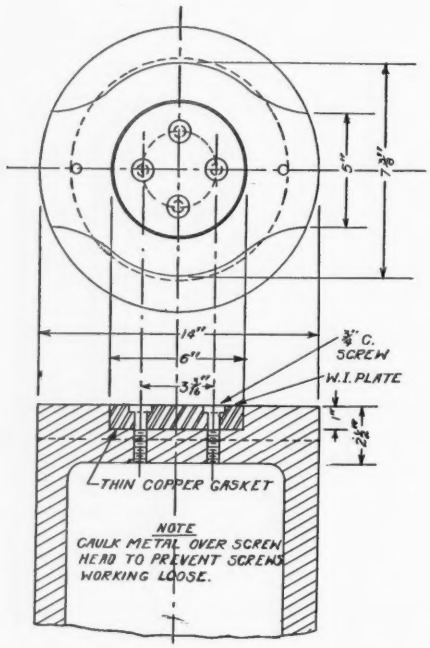


FIG. 2. METHOD OF MAKING REPAIR ON CYLINDER HEAD

This piston had been in operation in this engine for a period of something like 5 yr., and it seemed strange that it would give good service for so long and then develop this kind of trouble. At the time this happened, the engine in question was carrying an overload, for a period of about 2 hr. per day.

I had the hole in the top of the piston welded and put it back into service, but it blew out again in about 10 days. This time we calked copper in it and it held about 10 days again. Having it welded again, it held for about 30 days, during which time the one on the other side (number two) blew out in the same manner as the first.

When the first one opened up in the top it was thought that possibly it might be due to a shrink hole in the casting, and it had taken it just so long to show up, but when the second went out in the same way, this theory was blown up. Then it was thought the trouble was due to the intense heat in the head, caused from the engine being overloaded, but, about 30 days ago the third piston, the one shown in the photograph, Fig. 1, went out in the same way. This is a piston that we have had on hand that had a crack around the side about 4 in. long, which we had welded, and put in the number one cylinder to take the place of the one that gave us the first trouble, but when it went out the theory of overload causing the trouble was exploded, for the engine had not had to exceed 90 per cent rated load for two or three months.

The first piston to give trouble was repaired in the manner shown in the sketch, Fig. 2, and when the third piston went out, this one was put in its place.

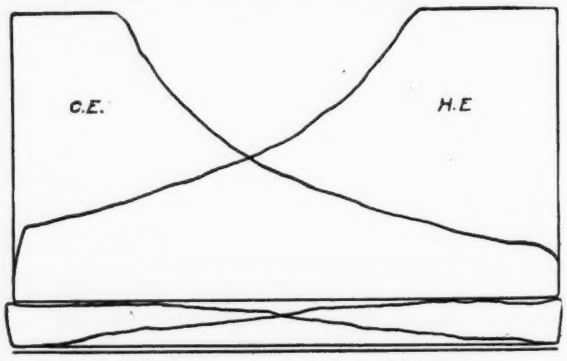
Now, if this engine was of the Diesel type, with compression in the head around 500 lb. per sq. in., it would be very easy to figure how the heads could be burned through, but, in the case of semi-Diesel engines, where the compression does not exceed 250 lb. per sq. in., and the explosive temperature should not go above about 1500 deg. F., it does not seem possible that these pistons could burn through in this manner; however, a word relative to the condition under which this engine has been operating may be valuable.

At the time we had the first trouble, this engine was timed approximately 7½ deg. ahead of the dead center, but when we had the last trouble, and for some time past, we have been operating with timing about 9 deg. ahead of dead center, at which point we seem to get the best operation. We are using about 28 to 30 gravity fuel oil, always keep the exhaust ports clean, have a cooling tower, and have perfect control of the cooling water temperature at all times. We have learned from experience that we get the best results with cooling water temperature around 130 deg. F., when operating with load, and around 160 deg. when operating at light load. We have had some trouble with scale in the cylinders and heads, but use a commercial acid, and keep them now practically free from scale.

We have a concrete exhaust pit with 128 cu. ft. capacity, into which there is a 10-in. exhaust pipe, 10 ft. long, leading from the bottom of the exhaust pot and entering the pit at one end about 18 in. above the bottom of the pit. This pit is built in rectangular shape, and is 4 by 4 by 8 ft. and has a stack about 20 ft. high, and 30 in. in diameter going up from one corner at the opposite end of the pit from where the exhaust pipe enters. The top of the pit is practically at the ground level. I. C. D.

What Should Be the Receiver Pressure

THE ACCOMPANYING cards were taken from a compound engine, equipped with a Meyer riding cutoff valve, driving a two-stage air compressor. Will the



INDICATOR CARDS FROM A RIDING CUT-OFF COMPOUND ENGINE

readers of Power Plant Engineering offer some suggestions as to how the operation of this engine may be bettered? Especially would I like to know whether or not the receiver pressure is right. The engine runs at 40 r.p.m., takes steam at 150 lb. throttle pressure, and exhausts to atmosphere. The receiver pressure is 21.5 lb. gage. C. D.

Heating System

WE HAVE a 54-in. by 14-ft. horizontal return tubular boiler with 44 3½-in. tubes which has been run on low pressure to serve a Paul vacuum heating system of the overhead type having a total radiation surface of approximately 4800 sq. ft. Vacuum is obtained by means of an injector. We burn liquid fuel, and, as the building is 10 stories high, we have ample draft. Although the boiler is run on low pressure, the state inspection allows us to carry 75 lb. pressure.

An addition to the building, in the course of construction, is to be equipped with a Vento heating system having the equivalent of 3200 sq. ft. of direct radiation. Has the boiler sufficient capacity to carry this additional load? It seems that it is good for 10,000 sq. ft., but it has been said that it was not large enough.

This Vento system is supposed to carry 2½ lb. pressure and the old system carries only 1 lb. or less. We also have a number of sheet iron radiators that are liable to leak, so that safety demands that the minimum pressure be used. It is thought that the boiler could be operated at 60 lb., but that would mean two reducing valves; one would be required if we carried 2½ lb. The returns come into the basement at less than 3 ft. above the boiler water level. Which would be more economical: to run it as a low-pressure plant, using trap and motor driven pumps; or at 60 lb. with steam driven pumps?

The problem of firing liquid fuel is complicated without high pressure steam. Burners that are dependent on electric motors for their operation are complicated and expensive as compared with steam atomizing burners. Aside from economy, is it true that there is less strain on the high pressure than on the low pressure boiler due to fluctuations in the load?

What is the relation between the efficiencies of a trap and a boiler feed pump? What per cent of the fuel fired to boiler is used to operate the boiler feed, vacuum, and fuel pumps and burner?

To change from low to high pressure, using steam vacuum, boiler feed and fuel pumps; installing reducing valves, pump governors, etc., would cost something less than $1000. A first-class burner for low pressure work will cost $750 and the extras will amount to about $200. Is there any gain one way or another as to first cost?

Would a vacuum pump used to handle the returns from the Paul lines to an open feed-water tank be of advantage or should we let the heating returns drain by gravity to the feed tank, using a dry vacuum pump to maintain the required vacuum?

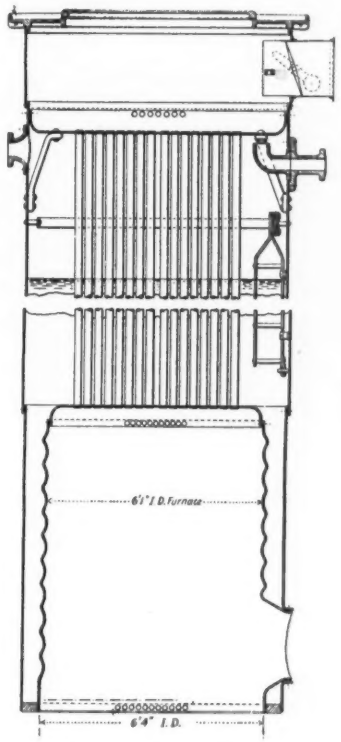
The returns from the two systems will be at different pressures, but I think that difficulty could be overcome by using a trap or perhaps a loop on the higher pressure lines.

Any opinions I can get on this problem will be highly appreciated. E. F. J.

Dean Boiler

ANSWERING J. A. H. who, in the March 15 issue of Power Plant Engineering on page 339, asks for a description of a Dean boiler:

The Dean boiler is named from its designer. It is a vertical fire-tube boiler built in large units. Many of these boilers are rated at 500 hp., and some are operated at 100 per cent or more above rating. The superheating is from 15 deg. to 40 deg. F. Some of these boilers are built with corrugated furnaces. The cylindrical shell is perfectly straight and the smoke-box is a direct extension of the shell. The smoke-flue leads from the side of the smoke-box, the top of which is covered with a magnesia filled cast-iron door. The boiler is of high-grade design throughout and is constructed with the



A LARGE DEAN BOILER

idea of combining great simplicity with high efficiency. The vertical joints are butt constructed with both inside and outside straps of the same width, and the riveting is arranged to give the highest possible efficiency. The two fire-doors are on the side, and, where a corrugated furnace is not used, the water leg fire-box is stayed, the stays have a ⅛-in. hole drilled in the outer end and are screwed in and riveted over. With the corrugated fire-boxes, staybolts are not needed, thus leaving the water space free of obstructions and making it easy for the inspector to enter the boiler. There is a ladder on the interior of the shell for the use of the inspector when examining the interior. This ladder is hung from rollers supported on a circular track so that the ladder can be shifted around the entire shell. One of the common sizes of these boilers has a grate 6 ft. in diameter, and a fire-box 5 ft. high, and has 376 2¼-in. diam. by 15 ft. tubes. Of this 15 ft. length an 11-ft. section is submerged and the other 4 ft. act as a superheating surface. The largest units have fireboxes that are more than twice the height of the one mentioned above, but in these large boilers the length of the tubes forming the superheating surface is not greater than in the smaller one. The tubes are perfectly straight and one extra heavy tube is used with a fusible safety plug located about 6 ft.

above the top of the lower tube plate. The fire-box is fitted with any standard grate, such as the Dillon or the St. John's. The ash pit forms the base of the boiler, and consists of a heavy casting with two large doors. The arrangement of the steam nozzle, handholes, the vertical joints, the fire-door, the feed water entrance, and some other details is shown in the accompanying sketch.

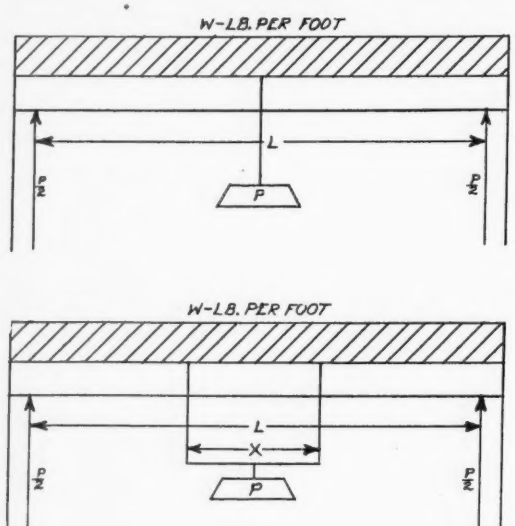
F. WEBSTER.

Carrying Capacity of Beams

WILL YOU KINDLY give me the formula for figuring the carrying capacity of an "I" beam, freely supported at both ends, supporting a concentrated load at the center and also at two points equidistant from the center?

E. G. M.

A. A beam freely supported at both ends and carrying a concentrated load at the center tends to bend downward at the center under the load. This tendency depends upon the amount of load, upon the distance between supports and upon the strength of the beam. The greater the load, the greater the distance between



ARRANGEMENT OF BEAM FREELY SUPPORTED AT BOTH ENDS AND CARRYING BESIDES A UNIFORM LOAD A CONCENTRATED LOAD IN THE CENTER IN THE FIRST CASE AND A DIVIDED LOAD CONCENTRATED AT TWO POINTS EQUIDISTANT FROM THE CENTER IN THE OTHER

supports, and the weaker the beam, the farther will it bend. The maximum capacity is that load which will not cause a permanent deflection to remain after it is removed.

Due to the bending of the beam, the lower surface is stretched or is subject to a tensile stress; the upper surface is compressed. It is the tensile strength which determines the load that can be carried. This stress is a maximum at the lower and upper surfaces and decreases gradually to the center, or center of gravity of the beam. For this reason, beams are not made rectangular in shape, but are so proportioned that most of the material is as close to the surface as possible.

Although the ultimate tensile strength of structural steel is about 70,000 lb. per sq. in. or for wrought iron 50,000 lb., the safe stress in the extreme fibers of a beam should be limited to from one-third to one-sixth of this amount depending on whether the load is dead or live. Assuming a live load on a steel beam the safe stress should not exceed $70{,}000 \div 6 = 11{,}666$ lb. per sq. in. This stress is equal to a quantity called the bending moment divided by what is known as the section modulus.

The bending moment varies for different positions along the beam, but for this particular case is greatest at the center. To find what its value is, we take moments about this section. If the load is P, the reaction, which is divided equally between the supports, will be $P \div 2$ at one end. The bending moment is then found by multiplying this reaction by its distance from the center, thus $M = P \div 2 \times L \div 2$ where L is the distance between supports. If the weight of the beam is to be considered we will have an additional moment. If the beam weighs w lb. per ft., the total additional load will be $w \times L$ and the reaction at the supports will be $w \times L \div 2$. Half of this load can be considered to be concentrated at a point halfway between the end and the center, and therefore we have a bending moment in the opposite direction. The additional moment is then $w \times L \div 2 \times L \div 2 - w \times L \div 2 \times L \div 4 = wL^2 \div 8$. The total bending moment is then $M = P \times L \div 4 + wL^2 \div 8$.

The section modulus is a quantity which is different for every variety of structural shapes, and is given in handbooks for all the common sizes and shapes of beams. For an "I" beam it is equal to $A\ H \div 3.2$ where A is the cross-sectional area of the beam in square inches and H is the depth of beam from face to face. In general, it is equal to a quantity called the moment of inertia of the section divided by ½ the distance from face to face. Expressed algebraically, it is $[(BH^3 - bh^3) \div 12] \div [H \div 12]$ where B is the breadth across the face and H the depth of the beam, b is the breadth minus the web thickness and h is the depth minus twice the flange thickness.

It thus develops that the maximum load which such a beam can carry is

$$S = (PL \div 4 + wL^2 \div 8) \div (A\ H \div 3.2)$$

For example, we will take a 5 by 10-in. I beam supported on 20-ft. centers and determine what weight it will safely carry at the center, neglecting the weight of the beam itself. S, for steel beams, is, as we found before, 11,666 lb.; with dimensions in inches the section modulus we find for this section, in a handbook, to be 31.7. Substituting these values in our equation, we obtain $11{,}666 = (P \times 20 \div 4) \div 31.7$, from which we get $P = 11{,}666 \times 31.7 \times 4 \div 20 = 74{,}000$ lb.

If the load is divided equally and applied at two points equidistant from the center of the beam, the only difference in the solution of the problem will be in finding the bending moment. Neglecting the uniform load due to the weight of the beam, the reaction at one support will be, as before, $P \div 2$; but instead of a single moment about the center we have two opposed moments, one due to the reaction and one due to one-half the load; the bending moment is now

$P \div 2 \times L \div 2 - P \div 2 \times X \div 2$ where X is the distance between the points of application of the load.

Suppose that our load, divided in two equal parts, is applied at two points 6 ft. apart, then $X = 6$, and sub-

stituting in our stress equation we get $11,666 = (P \times 20 \div 4 - P \times 6 \div 4) \div 31.7$ from which we find that $P \times 20 - P \times 6 = 11,666 \times 31.7 \times 4$, or $P = 11,666 \times 31.7 \times 4 \div (20 - 6) = 105,600$ lb.

From these two results, it will be seen that a much larger divided load than one single concentrated load may be carried on a given beam.

Boiler Inspection

WITH REFERENCE to the question of H. C. M. on page 633 of your June 15 issue as to what attention should be given a boiler and what inspections should be made before putting it up for summer: Before H. C. M. lays his boiler up, he should, first of all, have it tested by a qualified inspector, or, if one is not available, by the engineer in charge.

The boiler should be allowed to cool, as the blowoff cock should not be opened with the intention of blowing empty while the pressure exceeds 10 lb. per sq. in.

Remove as much of the soot and ashes as possible to allow the brickwork to cool down. When the boiler is cool, take the manhole plate off, leave blowoff cock open, and the damper and ash pit door shut to prevent any air from entering the boiler. When it is cold, go inside and scrape all the dirt off the plates, and clean the boiler thoroughly. Then examine all rivets, joints and plates especially the one on which the blowoff cock nipple is riveted. If on any of the plates, specks, the size of a dime, should appear, that would be pitting, and such spots should be scraped and afterwards cement washed, while on the other part of boiler plate only blunt instruments or hoop iron should be used to remove dirt or scale.

Should part of a plate appear to be peeling off, such layers ought to be removed, and should the plate be thereby made too thin to withstand the boiler pressure, it ought to be replaced with a new plate large enough to cover the affected area.

After seeing that the gusset stays or longitudinal stays and all other fittings on the boiler are correct and sound, the boiler plates should be tested with a light hammer, when the sound against the plates will, with a little practice, reveal a thin portion. If doubtful about any part of the plate not being thick enough, a ⅜-in. hole may be drilled, and, after removing the burr on each side, a piece of soft wood, shaped to fit the hole, pressed with a scriber or any other taper instrument against the edge of the plate, will cause its thickness to be impressed upon the wood, or a piece of lead wire may be used for the same purpose by similar treatment. It often happens that boilers of uncertain age appear perfectly sound, in which case the nature of the plate may be put to a test by applying a ½-in. punch and a hammer in the same way as if intending to pierce the plate; it will be found that a sound shell or tube will resist the blows, while boiler plates crystallized with age will soon allow the punch to leave an impression or even a hole. If, however, the plates be sound, and of sufficient thickness to bear the pressure the boiler is to carry, then put a rivet into the hole, which may have been bored; but should the plate have been pierced by the application of hammer and punch, the boiler should be rejected. Do not neglect to look around in the back connections for places where leakages might have been, which spots are generally detected by clusters of salt; these places should be well calked from both the inside and outside.

See that the boiler is filled with boiled water up to the safety valve, then close fire doors and ash pit doors, and put a cap on the smokestack. With this treatment, boilers do not rust inside or outside. It is the moist air drawn through an unused boiler that causes damage by rust. It is also a good plan to put a pail of lime on the grate bars to absorb any moisture that may be present.

RAYMOND J. ROE.

Relatives in the Boiler Room

WHAT IS the relation between the quantity of coal fired and the heating surface of a boiler?

2. What is the relation between the strength of an angle brace and that of a through stay?

3. What are the comparative densities of air and steam at 100-lb. pressure?

ANSWERS

1. A BOILER working at rating evaporates about 3½ lb. of water per square foot of heating surface per hour. Assuming that the boiler evaporates 7 lb. of water per pound of coal, this would mean that there would have to be 2 lb. of coal fired per square foot of heating surface per hour.

2. If a perpendicular brace of tensile strength, t, is required to support a certain section of a boiler, an angle brace would have to have strength $T = t \div \cos. a$ where a is the angle between the brace and perpendicular to the plate.

3. The density of both air and steam varies with the pressure. At 100 lb. pressure the steam weighs 0.2258 lb. per cubic foot; air at 32 deg. weighs 0.0807 lb. per cubic foot. From the equation $PV \div T = P_1V_1 \div T_1$, the volume and, consequently, the density, at 100 lb. pressure, 328 deg., can be found to equal 0.343 lb. per cu. ft.

It will be seen that at this pressure and temperature air is heavier than steam in proportion of 1.52 to 1.

Generating Power with Atmospheric Pressure

IS THE NORMAL atmospheric pressure, 14.7 lb. per sq. in., available for the production of mechanical energy, providing means can be found for employing it?

It appears to me that the normal atmospheric pressure of 14.7 lb. per sq. in., or approximately 2160 lb. per sq. ft. of earth's surface affords one of the greatest original sources of power for the production of mechanical energy; that is, provided means can be found for employing this pressure. Is this correct? Has any progress been made along this line? Can you give me an instance? J. M. W.

A. Normal atmospheric pressure, 14.7 lb. per sq. in., is available for the production of mechanical energy if there is a suitable medium available. For instance, exhaust steam at atmospheric pressure can be used with success in a turbine for generating power where a vacuum is obtainable. There are any number of plants which use this method of producing power where quantities of exhaust steam are available.

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Coal Regulation

This deals with the fundamental raw material of the steam driven power plant and is of vital importance to the plant manager. While storage of coal has been widely practiced, it is by no means universal with power plants, yet it is essential if coal production is to be uniform throughout the year.

Two legislative propositions are now being considered to that end; seasonal freight rates on coal; and compulsory publication of statistics of the coal industry, including amount produced, stocks on hand at mines and in yards, percentage of mine capacity operating and cost of production or price f.o.b. mine.

Seasonal freight, if the differential is sufficient to offset the cost of carrying the coal in storage, will help, as few plant managers, who have had experience with winter coal shortage, will fail to take advantage of stocking a reasonable reserve, cost being equalized. As to the value of statistics, there is more question. Price at the mine is helpful in determining whether the price asked for delivery at the plant is reasonable, and as such prices are open market data, there seems to be no reason why they should not be given full publicity. Stocks on hand will give a view of the state of the market, and likelihood of prompt delivery; but this information is the private business data of those holding the stocks, and, like rate of production and percentage of mine capacity in operation, does not seem naturally to be public property. If the mine operators and dealers agree to furnish this data for the good of the industry, it may be beneficial. Compulsory publication looks like government interference in private business, and is naturally resented. Unless we are prepared to advocate regulation of all industry by government, there seems no reason for singling out coal for special attention. "Less government interference in business. More business in government," is good sense.

Spite of the popular misconception that such institutions as the stock exchange and the produce exchange are a rich man's gambling game, there is merit in the suggestion (not legislative) for establishment of a coal exchange which will serve to stabilize the price of coal throughout the country. Abuses have crept into the working of existing exchanges, but there is a remedy in publicity, and members of the exchanges are anxious to clean house as soon as the bad practices are made known. Some national agency to regulate grading of coal, promulgate standards for specifications, deliveries, storage charges and handling charges would be of benefit. This might develop large storage yards, similar to grain elevators at central points throughout the country along lines similar to the present handling of export coal. And, if this was supplemented by supervision of grading and quality such as is exercised by the Grain Association, it would do much to establish confidence both here and abroad in the reliability of coal delivery. As coal is likely to be an important item of export in the future, confidence of foreign users is of importance to the industry.

Whatever of standardization and stabilization can be secured without introducing obnoxious government regulation will be of benefit to producers and users, but such development ought to come from those in the industry who are farseeing enough to realize the value of public confidence and the maximum service to their customers.

The effort of government, in the future, should be to assist private business, not hinder it, so long as it is carried on lawfully. With this in mind, as the avowed policy of the Department of Commerce, suggestions for improvement in business practice may well be given most careful consideration.

Experience vs. Theory

As the man who has come up from the ranks by hard work and study comes to understand the science underlying his work, and as the school-trained man comes to realize the need of modifying his book rules and formulas to take account of results shown in actual work, the gap lessens between experience and theory. The "shop man" within a few years has learned the real need of familiarity with the wide human experience to be found recorded in books and technical journals, and the "office man" has gone to the shop to correct his theory to conform to daily experience.

Evidently the engineer who follows rules of thumb, depending wholly on tradition, without understanding the principles and science of his work, and neglecting to check his rules by common sense and reasoning is quite as likely to fall into error as the one who relies wholly on science and mathematics, leaving out the results of experiment and work-a-day experience. The former needs to "go to school" and the latter needs to put on overalls; when the two exchange ideas and information, both are benefited.

As an example of confusion that may arise without understanding of principles is the much discussed question of the stress in cylinder head bolts of a steam engine under pressure. Neglect of the property of elasticity in bolts and flanges has led to much erroneous thinking and wasted argument.

On the other hand, no formulas for stress or knowledge of theory of design could ever allow for the "growth" of cast-iron pipe and fittings when used for superheated steam, and only after the fact was established was scientific explanation suggested in the oxidation of silicon in the cast iron, hastened by the stress and high temperature, although the increased rapidity of chemical action on metals under stress has long been known.

When it is realized that all science is the systematized result of experience—i. e., experiments and observation—and that theory is the application of known scientific principles to explain known results and endeavor to predict what will happen under like conditions, it is evident that the ideal statement should be Experience *plus* Theory and that any engineer who wishes to avoid mistakes and succeed in his work must strive always for this condition, checking the traditions of practice by the logic of science, and modifying his theoretical deductions by the known results from daily experience.

THE FRELINGHUYSEN coal stabilization bill and fact-finding bill have been sent back to committee by the Senate. This means that there will probably be no legislation affecting coal at this session. General opposition developed in the Senate which would in effect repeal the coal transportation act. This action was in line with the administration plan to confine the work of Congress to tax and tariff legislation in so far as possible.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Keep Your Chin Up

BY DR. FRANK CRANE

I AM going to tell you the truth about this naughty world, and the truth is that whichever way you're going, up or down, people want to help you along. If you are going up we all want to boost; if you are going down we all want to push. That is what we call sympathy.

You hear complaints that the rich are growing richer and the poor poorer. That has always been the case, simply because it is human nature. Society has always been organized to increase the wealth of the wealthy and the power of the powerful; also to make the weak weaker.

The rule is that "to him that hath shall be given, and from him that hath not shall be taken away even that which he hath."

There's no use whining about it. It is simply one of the flinty laws of nature. The only thing to do with nature's laws is to adjust one's self to them and not to complain.

This might be called the law of the inertia of prosperity.

If you have a hundred dollars ahead, to whom do you want to hand it? To the poor man who needs it? Not at all, but to the rich banker who does not need it.

If I ask you for the loan of a quarter you will pass it over to me without a word if you think it is a trifling matter to me; but if you suspect I really am in want and need the quarter to buy a little food with, that's quite another affair; you can't encourage that sort of thing; I should go to the Associated Charities.

Now, the way to use this law is to feign prosperity even if you have it not. Keep your chin up.

Wear good clothes. Don't withdraw from the society of the prosperous. Look pleasant. Don't let yourself get down at the heel. Don't get that poor beggar look on your face.

It isn't hypocrisy. It isn't pretense. It is sheer courage. It is letting the world know that while you live you purpose to fight, and that like Old General Taylor you "don't know when you're licked."

Keep smiling and an unfriendly universe will not know what to do with you; so it will crown you.

Says Alfred de Vigny: "All those that struggle against the unjust heavens have had the admiration and secret love of men."

Fate is a bluff. Face her, defy her, and she will fawn on you.

Fate is cruel, but only to the quitter.

* Copyright, 1921, by Dr. Frank Crane.

A Multiphase Renewable Fuse

THE FEDERAL ELECTRIC CO., of Chicago, has developed a low voltage auxiliary coil which is embodied in the renewable cartridge of the fuses, and as the cartridge can go into the case in but one position, it easily makes the auxiliary connection with the fuse case itself.

Leads are then brought out for connecting the interphase circuit in either delta or "Y" connection and is

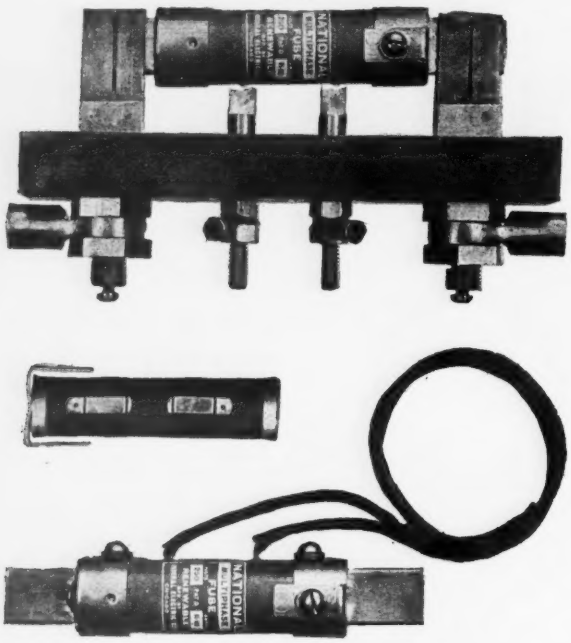

FIG. 1. MULTIPHASE RENEWABLE FUSE

made with either wire connections attached to the case for front connecting, or auxiliary knife-blade connections are attached for back connecting on panels, switchboards, etc.

This new device serves two purposes. First, as a fuse it is so constructed that it withstands the high start-

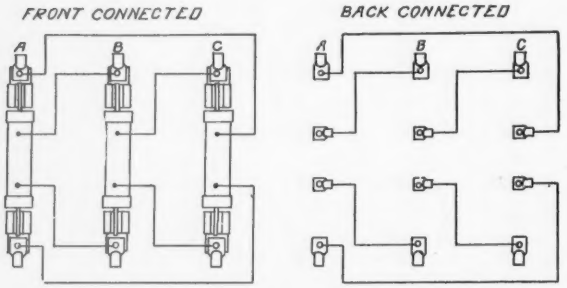

FIG. 2. DIAGRAMS OF CONNECTIONS

ing current of motors, yet protects the running load within the limits prescribed by the Underwriters' Laboratories, Inc. It is powder-packed, and has the metallic telltale indicator which shows in plain view upon the outside of the fuse the rated amperage of the element with which the fuse is loaded. As the fuse is made for operation on multiphase circuit, it acts as a circuit breaker; that is, when one fuse blows, the auxiliary device in the fuse makes one of the other elements in one of the other fuses blow, thereby breaking the circuit entirely and eliminating the possibility of the motor running as a single phase motor. This is really a time limit fuse.

The two greatest causes of motor interruption are the overloading of fuses by placing two or more elements or an element of too great a capacity in the fuse case and the running of motors as single phase. It is impossible to place more than one element in the fuse. As this type of fuse assures the breaking of the circuit when one fuse blows, it means the highest protection possible to multiphase motors and circuits at only a slight additional cost over the ordinary renewable fuse.

Rotary Pump

THE EXETER rotary pump is based upon a new idea of rotary pump construction. The pump creates its own suction, its action is positive, and the flow of the water is continuous. There are no valves and no reciprocating parts and, compared with its output, the size is small.

Broadly speaking, the underlying principle is a variant of the square hole drilling device in which a triangular bit functions inside a restraining square former of equal size. This combination has been developed as a three-tooth gear meshing with an internal four-tooth gear set eccentrically one to the other. The

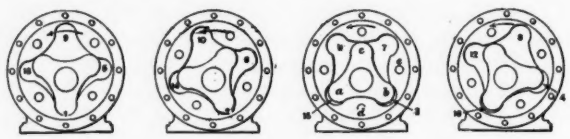

FIG. 1. STAGES IN THE CYCLE OF OPERATION OF THE PUMP

irregular spaces increasing and diminishing in volume as the two rotate together are utilized to admit and eject the fluid. Using an equilateral triangle inside a square will, of necessity, give the greatest vacant space in relation to the size of the contacting pair. Any other combination, four to five, five to six, etc., will more nearly approach equal size and consequently leave less void.

Taking the illustrations in Fig. 1, in sequence, the space 9 between the two rotors is at the maximum; the inlet port has just closed and the outlet port is about to open. The entire cycle of movement and variation of one space can be progressively followed through the four diagrams by the numbers 1 to 16. Starting with maximum volume as 9, then going to 10, 11, 12, 13, 14, 15, 16, 1, 2, 3, 4, 5, 6, 7, 8, and 9 completes the progression. The capacity of the pump per revolution is equal to three times the volume of space 9.

The pump consists of an outer casing of cylindrical form having a pair of rotors meshing, the inner rotor being keyed to the driving shaft. These two rotors are set eccentric one to the other. The outer rotor has four ports which are open to the chamber of both the suction and discharge side of the pump during rotation. These ports are closed momentarily by a lip at both the

top and the bottom of the pump body in order to effect the cutoff between the suction and the discharge of the pump. The liquid is drawn into the pump through the ports of the outer rotor while the pocket is increasing and forced out at the opposite side of the pump during the last half revolution when the pocket is decreasing.

The rotors themselves are flat castings of suitable thickness, worked on edge to the figures described, their faces being in parallel planes. The outer rotating member is a working fit in the casting at its periphery and is otherwise free, the inner rotor imparting motion to the outer.

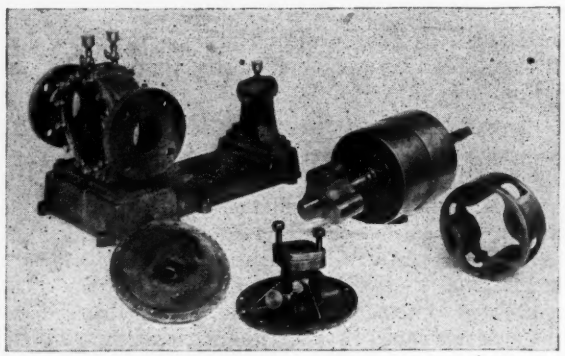

FIG. 2. DISSEMBLED VIEW OF EXETER ROTARY PUMP

This pump is suitable for pumping water for irrigation, barometric condensers, suction roll work, evaporation pans, boiler feed, circulating, lubricating or wet vacuum work, and is manufactured by the Dexter Machine Works, in West Pittston, Pa.

Pneumatic Governor

AS ONE OF the most recent improvements in turbine design, we find a pneumatic speed controlling device which is quite a departure from either the flyball or oil pressure relay type. This device operates due to the change in pressure of air occasioned by a change in speed of an impeller, which is the only revolving element. This design is used on both the high and low pressure machines and also on the mixed pressure type manufactured by the Ridgway Dynamo & Engine Co.

The operation is essentially as follows: Air pressure generated by the fan, whose impeller is direct-connected to the turbine shaft, is transmitted to the under side of two light aluminum pistons opposed by a spring. The upper end of the stem carrying these pistons is pivoted to one end of a floating lever. At the center of this lever the stem of a small pilot valve is attached and at the other end is pivoted the stem of the main oil piston controlling the balanced steam admission valves. The governor for a high pressure machine is shown in Fig. 1.

The system is applicable through a selective mechanism to a mixed pressure machine. Figure 2 shows a diagrammatic layout of the mechanism. Any increase in the speed of the turbine will mean a simultaneous increase in fan speed with a corresponding increase in pressure which varies as the square of the speed. The pressure increase will raise the air piston and through the floating lever will lift the pilot valve. This valve in lifting opens a port to allow oil under a pressure of 35 lb. to act on the upper side of the main oil piston. This piston is forced down and tends to close both or either the high or low pressure valves depending on the position of the selective linkage. At the same time,

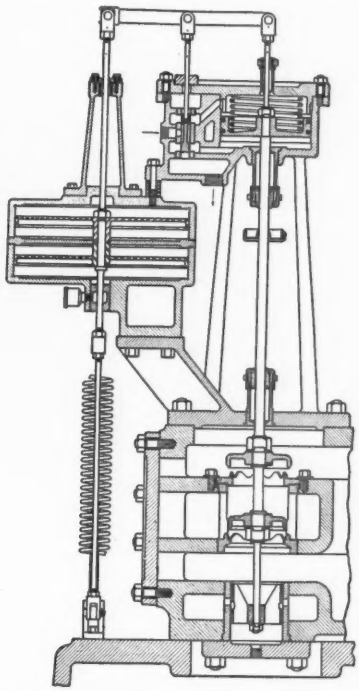

FIG. 1. HIGH-PRESSURE GOVERNOR

the pilot valve is lowered to its normal position and the speed drops to normal.

Suppose that the turbine is using both high and low pressure steam, the pressure in the low pressure line will partially lift the piston of the selective cylinder

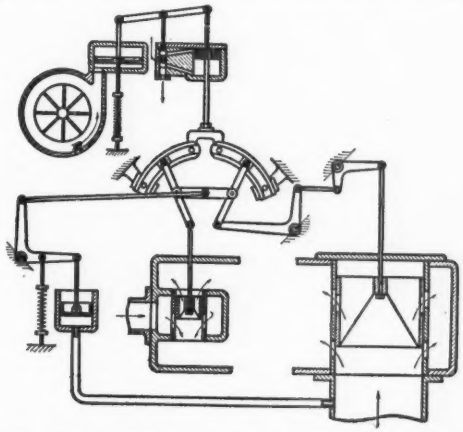

FIG. 2. DIAGRAMMATIC LAYOUT OF MIXED PRESSURE GOVERNOR WITH SELECTIVE MECHANISM

on the left, Fig. 2, which, through a bell crank connection, moves the high pressure link block over toward the fixed center of its link so that the movement of the governor affects the low pressure valve more and the other less.

If the low pressure supply is cut off, the pressure in

this line falls and the selective piston drops moving the low pressure link block to the fixed center of its link and allowing the governor to affect only the high pressure valve. If there is a superabundance of low pressure steam, the selective piston is raised thus the linkage is arranged so that the governor action will effect mainly the low pressure valve.

The action is claimed to be extremely rapid, requiring only a fraction of a second from the instant the change occurs until the speed is back to its normal value. It is also claimed that although the regulation is rapid there is no tendency toward surging or hunting.

News Notes

EVERLASTING VALVE CO. moved its general office, including the sales department, on June 10, from New York to the manufacturing plant, Jersey City, N. J.

CHARLES COPELAND, assistant treasurer, has been elected a member of the board of directors and secretary of the E. I. duPont de Nemours & Co. to fill the vacancy caused by the death of Alexis I. duPont.

THE LINK-BELT CO. has acquired all of the capital stock of the H. W. Caldwell & Son Co., and Frank C. Caldwell has been elected a director of the Link-Belt Co. Two experienced and successful companies in the conveyor world have thus joined forces, with the result that the Link-Belt Co. has added two new lines, helicoid conveyors and power transmission machinery, to its line of manufactures. The H. W. Caldwell & Son Co.'s plant will continue to operate under separate corporate existence and under its present name.

T. JULIAN MCGILL, manager of the Chicago office of the Westinghouse Electric & Mfg. Co., has resigned to become vice-president of the Twin City Rapid Transit Co. of Minneapolis and St. Paul, in charge of operation and public policy. N. G. Symonds, manager of the industrial division of the Chicago office, has been appointed manager succeeding T. Julian McGill. The territory under the jurisdiction of this office includes North Dakota, Minnesota, Wisconsin, Iowa and parts of Nebraska, South Dakota, Illinois, Indiana and Michigan.

Book Reviews

ENGINEERING OF POWER PLANTS by Robert H. Fernald and George A. Orrok; second edition, 595 pages, illustrated, 6 by 9, cloth; New York, 1921.

As a text, this book aims to emphasize the fact that engineering, as applied to the design of power plants, although based on the exact science, is not inself an exact science but requires on the part of the engineer, the use of good sound common horse sense and the application of engineering judgment; and to give the student some insight into the commercial, the dollars and cents side of engineering, a side but infrequently touched upon in many engineering courses.

The work is not supposed to be a treatise on the subject of power plants; it is rather an abbreviation of the subject for convenient classroom use.

Many well chosen illustrations are included in the text, and frequent resort is made to tables and charts.

HANDBOOK OF STANDARD DETAILS by Charles H. Hughes; 312 pages, illustrated, 4¾ by 7, cloth; New York, 1921.

This book was compiled especially for engineers and draftsmen and contains drawings of and formulas for standard details used in machine design. Many of the specifications were obtained from leading machine tool manufacturers and represent current practice.

Sections are included on drawings; fastenings; power transmission; pipes, tubes and fittings; rope and chain fittings; miscellaneous details; structural details; and useful tables.

THE ENGINEERING INDEX for 1920, compiled by the American Society of Mechanical Engineers; 586 pages, 6½ by 9¼, cloth; New York.

This volume is a compilation of the indexes which the society publishes monthly. It indexes nearly 14,000 technical articles which have appeared during the year in some 700 engineering and allied publications. Each item listed contains the exact title of the article indexed; the author's name, if given; the name of the periodical in which the article appeared; the volume, number and date of publication and the page numbers, and number of figures in the article. It also includes a brief note summarizing the article indexed. This feature, together with the numerous cross-references, makes it possible for one to confine his search along any one definite line.

Catalog Notes

CONTROL APPARATUS is the subject of Descriptive Leaflet 3982, just being distributed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Type F magnetic-switch double-section control panels are featured, together with Type 22-F magnetic-switch control panels. Line diagrams and dimension diagrams of apparatus are listed.

BULLETIN No. 49,011 issued by the General Electric Co., describes running light telltale boards. These boards afford an accurate and reliable means of indicating whether or not the running lanterns are properly lighted on vessels using electricity for lighting. This bulletin supersedes descriptive sheet No. 69,011 and bulletin 4816.

Provision is made on the board for both audible and visible warnings in case of the failure of any of the lamps. It is also possible by means of snap switches to throw into the circuit the second lamp with which running lights are usually provided, in order to avoid the inconvenience of replacing lamps in rough weather.

The panel method is used in the construction of these boards, and the bulletin shows by illustrations and diagrams how they are operated. The right-hand panel usually contains the buzzer signal and warning lamp receptacle and the others provide control of the lanterns located in various parts of the vessel. These boards are designed for operation on circuits of 110 to 125 v., but can be adapted for use on circuits of higher or lower potential. Fuses are provided on all circuits and the sockets are made for lamps with standard Edison bases. Small nickel-plated name plates are furnished when desired for labeling each of the lantern circuits.